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MICHAEL E. KLICPERA
PO BOX 573
LA JOLLA, CA 92038-0573

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RIMELL, SAMUEL G	

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Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

PTOL-90A (Rev. 04/07)

Order Granting Request For Ex Parte Reexamination	**Control No.** 90/014,355	**Patent Under Reexamination** 9749792	
	Examiner SAM RIMELL	**Art Unit** 3992	**AIA (FITF) Status** No

--The MAILING DATE of this communication appears on the cover sheet with the correspondence address--

The request for *ex parte* reexamination filed 08/05/2019 has been considered and a determination has been made. An identification of the claims, the references relied upon, and the rationale supporting the determination are attached.

Attachments: a)☐ PTO-892, b)☑ PTO/SB/08, c)☐ Other: ____

1. ☑ The request for *ex parte* reexamination is GRANTED.

RESPONSE TIMES ARE SET AS FOLLOWS:

For Patent Owner's Statement (Optional): TWO MONTHS from the mailing date of this communication (37 CFR 1.530 (b)). **EXTENSIONS OF TIME ARE GOVERNED BY 37 CFR 1.550(c).**

For Requester's Reply (optional): TWO MONTHS from the **date of service** of any timely filed Patent Owner's Statement (37 CFR 1.535). **NO EXTENSION OF THIS TIME PERIOD IS PERMITTED.** If Patent Owner does not file a timely statement under 37 CFR 1.530(b), then no reply by requester is permitted.

/SAMUEL G RIMELL/ Primary Examiner, Art Unit 3992	/ANGELA M LIE/ Primary Examiner, Art Unit 3992	

cc:Requester (if third party requester)

DECISION GRANTING EX PARTE REEXAMINATION

The Request filed August 5, 2019 asserts that substantial questions of patentability (SNQ) affecting claims 1-34[1] of the U.S. Patent Number 9,749,792 are raised by the following prior art references. Each reference listed is admitted to be prior art under 35 USC §102 and 35 USC §103:

(PA 1) "Energy Manager-Water Leak Detection" II.S. Patent 9,019,120 to Broniak et al, issued April 28, 2015, filed November 9, 2010.

(PA 2) "Water Management System" U.S. Published Application 2011/0035063 to Palayur, published February 10, 2011, filed October 14, 2010, priority claim to October 20, 2009.

(PA 3) "Valve Meter Assembly and Method" U,S. Patent 8,833,390 to Ball et al, issued September 16, 2014, filed May 31, 2011.

(PA 4) "Systems and Methods for Monitoring and Controlling Remote Devices" U.S. Patent 8,013,732 to Petite et al, issued September 6, 2011, filed June 3, 2009, priority claim to August 2, 1999.

(PA 5) "Microprocessor Controlled Water Shut-Off Device" U.S. Patent 6,105,607 to Caise et al, issued August 22, 2000, filed July 9, 1999, priority claim to June 15, 1998.

(PA 6) "Water Leakage and Fault Sensing System" U.S. Published Patent Application 2008/0295895 to Vincent et al, published December 4, 2008, filed May 30, 2007.

(PA 7) "Water Meter with Integral Flow Restriction Valve" U.S. Patent 8,539,827 to Benson et al, issued September 24, 2013, filed January 31, 2011.

(PA 8) "Method and System for Providing Web-Enabled Cellular Access to Meter Reading Data U.S, Patent 8,644,804 to Blackwell et al, issued February 4, 2014, filed October 2, 2009.

[1] The petition at page 4, third paragraph, states that reexamination is requested for claims 1,2,5,6, 10, 12,17, 24-27, 29, 31 and 34. However, at page 5 of the request, prior art is asserted as raising an SNQ against all of claims 1-34 in the issue "CC3". Accordingly, we determine that requester is requesting reexamination of all the claims 1-34.

(PA 9) “AMR Transmitter and Method Using Multiple Radio Messages" U S Patent 8,878,690 to Olson et al, issued November 4, 2014, filed June 23, 2009.

(PA 10) “Modular Wireless Fixed Network for Wide-Area Metering Data Collection and Meter Module Apparatus” U.S. Patent 7,012,546 to Zigdon et al, filed July 22, 2002, priority claim to September 13, 2001.

(PA 11) “Modular Wireless Fixed Network for Wide-Area Metering Data Collection and Meter Module Apparatus” U.S. Patent 8,269,651 to Zigdon et al, issued September 18, 2012, filed February 15, 2006, priority claim to September 13, 2001.

(PA 12) “AMR Transmitter and Method for Both Narrow Rand and Frequency Hopping Transmissions” U.S. Patent 7,626,511 to Lazar, issued December 1, 2009, filed June 12, 2006.

(PA 13) “Multi-Band Channel Capacity for Meter Network”, U.S. Patent 9,253,754 to Sanderford Jr., published February 2, 2016, filed December 21, 2011, priority to December 23, 2010.

(PA 14) “AMR Transmitter and Method Using Multiple Radio Messages” U.S.Patent 9,417,093 to Olson et al, published August 16, 2016, filed November 3, 2014, priority to June 23, 2009.

(PA 15) “Method and System for Providing Web-Enabled Cellular Access to Meter Reading Data" U.S, Patent 9,709,421 to Blackwell et al, issued July 18, 2017, filed February 3, 2014, priority to October 2, 2009.

Brief Overview of the US Patent 9,749,792

The present invention is a water use and/or a water energy use monitoring apparatus that is affixed to the hot and cold water supply piping for continuously (or on demand) monitoring displaying the water and water energy (hot vs. ambient) use within a residential or commercial

building. The water use monitor apparatus includes a power generation, a microprocessor, temperature and water flow sensors, optional water quality sensors, timing circuits, wireless circuitry, and a display means. A wired or wireless means is designed to electronically communicate water use, water energy use and/or water quality information to a remotely located display apparatus or typical cell phone, smart phones, or similar apparatus for convenient observation by a commercial, operator or occupier, resident, municipal or government agency (see abstract).

Prosecution History of US Patent 9,749,792

The following applications establish the chain of priority claims leading up to the issuance of US Patent 9,749,792:

Priority Claim Chart

Serial Number	Filing Date	Patent	Issue Date	Abandon Date
14/596,460 (CIP)	1/14/2015	9,749,792	8/29/2017	
14/561,271 (CIP)	12/5/2014	9,494,480	11/15/2016	
13/776,963 (CIP)	2/26/2013	9,297,150	3/29/2016	
12/539,150 (CIP)	8/11/2009	9,061,307	6/23/2015	
62/095,024	12/21/2014			1/21/2014

The final application in the chain of applications leading up to the issuance of US patent 9,749,792 was application 14/596,460, filed on January 14, 2015.

On December 22, 2016, the USPTO mailed a non-final office action. Claims 1-27 were rejected under the judicial doctrine of obviousness type double patenting in view of claims 1-34

of 9,494,480. Claims 1-27 were also rejected under 35 USC 112, second paragraph. This office action at pages 9-10 also indicates patentable subject matter within claims 1-2, described as follows:

"***The following is a statement of reasons for the indication of allowable subject matter: the prior art fails to disclose or render obvious in independent claim 1 the following "said base station functions as a mesh-enabled device such it can communicate with other base stations which in combination function as signal repeaters for transferring water flow, water energy and/or water quality data to a particular access point, said access point transfers said water flow, water energy and/or water quality data, using encryption and identification technology to the internet, and; said water flow, water energy and/or water quality data transferred over the internet to one or more remote computer servers, said remote computer or servers allow registered owners and users to access their registered water flow, water energy and/or water quality data using a cell phone, smart phone or similar apparatus" and***

In independent claim 2 the following: "said receiving station having the capability to coordinate mesh-enabled technology, whereby said receiving station can receive water flow, water energy and/or water quality data from two or more base stations; said receiving station optionally has mesh-enabled technology such said receiving station can communicate with other receiving stations which in combination function as signal repeaters for transferring water flow, water energy and/or water quality data to a particular access point, said access point transfers said water flow, water energy and/or water quality data to the internet, said access point can be a receiving station or custom transfer apparatus; and said water flow, water energy and/or water quality data transferred over the internet to one or more remote computer servers" in combination with the other limitations set forth in the independent claims".

On April 22, 2017, applicant submitted a response with remarks, claims amendments, affidavits under 37 CFR 1.131 and a declaration under 37 CFR 1.132. On May 9, 2017, applicant further submitted a terminal disclaimer.

On May 23, 2017, the USPTO sent out a notification that the terminal disclaimer was disapproved.

On June 5, 2017, applicant submitted a revised terminal disclaimer.

On June 5, 2017, the USPTO sent out a notification that the terminal disclaimer of the same date (June 5, 2017) was approved.

On June 5, 2017, the USPTO sent out a final office action. Claims 1-34 were rejected under 35 USC 112, second paragraph.

On June 7, 2017, applicant submitted a response with remarks and amendments.

On June 28, 2017, the USPTO issued a Notice of Allowance.

Effective Filing Date of Claims Requested for Reexamination

Requester seeks reexamination of claims 1-34 of US Patent 9,749,792. The effective filing date for this claim set is January 14, 2015.

The feature of "registered owners" only first appears in the independent claims 1-2 of US Patent 9,749,792. Since this feature resides in each of the independent claims, all of claims 1-34 possess an effective filing date which does not precede the filing date of US Patent 9,749,792, namely January 14, 2015.

Each prior art reference asserted by applicant is available as prior art under 35 USC §102 and 35 USC §103, based on the effective filing date.

Treatment of Preliminary Amendments

For purposes of evaluating substantial new questions of patentability (SNQs), only the content of the original patent are considered. As a result, preliminary amendments to either the specification or the claims are not considered at this initial stage of the reexamination. See MPEP 2243, last paragraph, and 37 CFR 1.515(a).

Substantial New Questions of Patentability (SNQs) Asserted in the Request

SNQ #1: Whether Broniak et al raises an SNQ in view of claims 1, 2, 4, 6, 13, 24, 25, 26 and 31 of US Patent 9,749,792.

SNQ #2: Whether Palayur raises an SNQ in view of claims 1, 2, 4, 5, 6, 24, 25, 26 and 34 of US Patent 9,749,792.

SNQ #3: Whether Broniak et al and Palayur taken together raise an SNQ in view of claims 1-34 of US Patent 9,749,792.

SNQ #4: Whether Ball et al raises an SNQ in view of claims 1, 2, 5, 6, 24, 25, 26 and 34 of US Patent 9,749,792.

SNQ #5: Whether Broniak et al and Palayur and Ball et al taken together raise an SNQ in view of claims 1, 2, 5, 6, 10, 13, 17, 24, 25, 26, 31 and 34 of US Patent 9,749,792.

SNQ #6: Whether Broniak et al and Palayur and Ball et al and Petite et al taken together raise an SNQ in view of claims 1, 2, 5, 6, 10, 13, 17, 24, 25, 26, 31 and 34 of US Patent 9,749,792.

SNQ #7: Whether Broniak et al and Palayur and Ball et al and Caise et al taken together raise an SNQ in view of claims 1, 2, 5, 6, 10, 13, 17, 24, 25, 26, 31 and 34 of US Patent 9,749,792.

SNQ #8: Whether Broniak et al and Palayur and Ball et al and Vincent et al taken together raise an SNQ in view of claims 1, 2, 5, 6, 10, 13, 17, 24, 25, 26, 31 and 34 of US Patent 9,749,792.

SNQ #9: Whether Benson et al raises an SNQ in view of claims 1, 2, 4, 5, 6, 24, 25, 26 and 34 of US Patent 9,749,792.

SNQ #10: Whether Blackwell et al ('804) raises an SNQ in view of claims 1, 2, 4, 5, 6, 24, 25, 26 and 34 of US Patent 9,749,792.

SNQ #11: Whether Olson et al ('690) raises an SNQ in view of claims 1, 2, 4, 5, 6, 24, 25, 26 and 34 of US Patent 9,749,792.

SNQ #12: Whether Zigdon et al ('546) raises an SNQ in view of claims 1, 2, 4, 5, 6, 24, 25, 26 and 34 of US Patent 9,749,792.

SNQ #13: Whether Zigdon et al ('651) raises an SNQ in view of claims 1, 2, 4, 5, 6, 24, 25, 26 and 34 of US Patent 9,749,792.

SNQ #14: Whether Lazar raises an SNQ in view of claims 1, 2, 4, 5, 6, 24, 25, 26 and 34 of US Patent 9,749,792.

SNQ #15: Whether Sanderford, Jr raises an SNQ in view of claims 1, 2, 4, 5, 6, 24, 25, 26 and 34 of US Patent 9,749,792.

SNQ #16: Whether Olson et al ('093) raises an SNQ in view of claims 1, 2, 4, 5, 6, 24, 25, 26 and 34 of US Patent 9,749,792.

SNQ #17: Whether Blackwell et al ('421) raises an SNQ in view of claims 1, 2, 4, 5, 6, 24, 25, 26 and 34 of US Patent 9,749,792.

Legal Standard for a Substantial New Question of Patentability (SNQ)

The legal standard for ordering *ex parte* reexamination, as set forth in 35 U.S.C. 303(a), requires a substantial new question of patentability.

A prior art patent or printed publication raises a substantial question of patentability where there is a substantial likelihood that a reasonable examiner would consider the prior art patent or

printed publication important in deciding whether or not the claim is patentable. If the prior art patents and/or publications would be considered important, then the examiner should find "a substantial new question of patentability" unless the same question of patentability has already been decided as to the claim in a final holding of invalidity by a federal court or by the Office in an earlier concluded examination or review of the patent, or unless the same question of patentability has been raised to or by the Office in a pending reexamination or supplemental examination of the patent.

The substantial new question of patentability may be based on art previously considered by the Office if the reference is presented in a new light or a different way that escaped review during earlier examination. The clarification of the legal standard for determining obviousness under 35 U.S.C. 103 in *KSR International Co. v. Teleflex Inc.* (KSR), 550 U.S. 398, 82 USPQ2d 1385 (2007) does not alter the legal standard for determining whether a substantial new question of patentability exists. The requirement for a substantial new question of patentability remains in place even if it is clear from the record of a patent for which reexamination is requested that the patent was granted because the Office did not show "motivation" to combine, or otherwise satisfy the teaching, suggestion, or motivation (TSM) test. Thus, a reexamination request relying on previously applied prior art that asks the Office to look at the art again based solely on the Supreme Court's clarification of the legal standard for determining obviousness under 35 U.S.C. 103 in *KSR*, without presenting the art in new light or different way, will not raise a substantial new question of patentability as to the patent claims, and reexamination will not be ordered.

After the enactment of the Patent and Trademark Office Authorization Act of 2002 ("the 2002 Act"), a substantial new question of patentability can be raised by patents and printed publications "previously cited by or to the Office or considered by the Office" ("old art"). The

2002 Act did not negate the statutory requirement for a substantial new question of patentability that requires raising new questions about pre-existing technology. In the implementation of the 2002 Act, MPEP § 2242, subsection II.A was revised. The revision permits raising a substantial new question of patentability based solely on old art, but only if the old art is "presented/viewed in a new light, or in a different way, as compared with its use in the earlier examination(s), in view of a material new argument or interpretation presented in the request." Thus, a request may properly raise a substantial new question of patentability by raising a material new analysis of previously considered reference(s) under the rationales authorized by *KSR*.

Analysis of SNQ Issues

SNQ #1: Does Broniak et al raise an SNQ in view of claims 1, 2, 4, 6, 13, 24, 25, 26 and 31 of US Patent 9,749,792?

FIG 1 of Broniak et al illustrates a "central controller 10" which is connected to a utility meter 13 that is in turn connected to a utility, such as water flow. The central controller thus corresponds to the "*base station*" as set forth in claim 1-2 of US Patent 9,749,792. Via control over a laptop 36 or cellphone 38, the central controller 10 communicates with the Internet 40. The control controller 10 is thus "*mesh enabled"* in that it can communicate from the single point of the central controller 10, to multiple points over the Internet. This corresponds to the "*mesh enabled*" functionality of claims 1-2 of US Patent 9,749,792. . FIG 1 of Broniak et al further illustrates a memory 30 with a table 32 to collect water consumption data, energy consumption data or generation data (col. 5, lines 60-62). The memory 30 with table 32 is connected to the Internet so as to allow external servers 42 access to the data within the memory. This indicates that the central controller 10 is also "*an access point that transfers said water flow, water energy or water quality data…to an internet connection*" as set forth in claims 1-2 of US Patent 9,749,792.

There is a substantial likelihood that a reasonable examiner would consider the Broniak et al patent important in deciding whether or not claims 1-2 of US Patent 9,749,792 are patentable. The same question of patentability has not already been decided as to the claim in a final holding of invalidity by a federal court or by the Office in an earlier concluded examination or review of the '792 patent. The same question of patentability has not been raised to or by the Office in a pending reexamination or supplemental examination of the '792 patent.

Accordingly, Broniak et al raises an SNQ with respect to claims 1-2. Since each of claims 4, 6, 13, 24, 25, 26 and 31 incorporate the subject matter of claims 1 or 2 by reference, an SNQ is additionally raised by Broniak et al for this set of dependent claims.

SNQ #2: Does Palayur raises an SNQ in view of claims 1, 2, 4, 5, 6, 24, 25, 26 and 34 of US Patent 9,749,792?

FIG 1 of Palayur illustrates a base unit 1 which is connected to the Internet 12 with water meters 2 and 4. These water meters 2 and 4 are in turn connected to water utility sources. The base unit 1 generally corresponds to the "*base station*" as set forth in claim 1-2 of US Patent 9,749,792. Since the base unit 1 is a single access point connected to the Internet 12 and connected to multiple external access points, such as water meters w2 and 4 and/or water company 14, the base unit 1 would considered "*mesh enabled*" as recited in in claim 1-2 of US Patent 9,749,792. FIG 6 of Broniak et al illustrates a control logic that monitors water usage against daily and monthly quotas against a preset usage threshold. Monitoring is also provided for the possibility of a flush tank leak. The processor and control logic which perform these steps will generally correspond to "*an access point that transfers said water flow, water energy or water quality data…to an internet connection*" as set forth in claims 1-2 of US Patent 9,749,792.

There is a substantial likelihood that a reasonable examiner would consider the Broniak et al patent important in deciding whether or not claims 1-2 of US Patent 9,749,792 are patentable. The same question of patentability has not already been decided as to the claim in a final holding of invalidity by a federal court or by the Office in an earlier concluded examination or review of the '792 patent. The same question of patentability has not been raised to or by the Office in a pending reexamination or supplemental examination of the '792 patent.

Accordingly, Broniak et al raises an SNQ with respect to claims 1-2. Since each of claims 4, 6, 13, 24, 25, 26 and 31 incorporate the subject matter of claims 1 or 2 by reference, an SNQ is additionally raised by Broniak et al for this set of dependent claims.

SNQ #3: Does Broniak et al and Palayur taken together raise an SNQ in view of claims 1-34 of US Patent 9,749,792?

Each of Broniak et al and Palayur have been individually demonstrated herein to raise an SNQ with respect to independent claims 1 and 2 (SNQs #1 and #2). Accordingly, the combination of the two references will equally raise an SNQ with respect to claims 1 and 2. Since each of claims 3-34 incorporate the subject matter of claims 1 or 2 by reference, an SNQ is additionally raised by the combination of Broniak et al and Palayur for this set of dependent claims.

SNQ #4: Does Ball et al raises an SNQ in view of claims 1, 2, 5, 6, 24, 25, 26 and 34 of US Patent 9,749,792?

FIG 29 of Ball et al illustrates a "wireless communication unit 2310" which is remotely controllable through remotely located communicators 2985' and 2985''. Accordingly, the "wireless communication unit 2310" corresponds to a "*base station*" as set forth in claims 1-2 of the '792 patent. Since the wireless communication unit 2310 is a single access point connected to the Internet 2975 and connected to multiple external access points, such external wireless

communication units 2..n, the wireless communication unit 2310 would considered "*mesh enabled*" as recited in in claim 1-2 of US Patent 9,749,792.

Referring to FIG 30 of Ball et al, a set of register values (values registered by a utility meter) are read and recorded at step 3030. As illustrated in FIG 29, this action is performed by the register circuit 2910. Also see col. 16, lines 28-40. Accordingly, the register circuit generally corresponds to "*an access point that transfers said water flow data…to an internet connection*" as recited in in claims 1-2 of US Patent 9,749,792.

There is a substantial likelihood that a reasonable examiner would consider the Ball et al patent important in deciding whether or not claims 1-2 of US Patent 9,749,792 are patentable. The same question of patentability has not already been decided as to the claim in a final holding of invalidity by a federal court or by the Office in an earlier concluded examination or review of the '792 patent. The same question of patentability has not been raised to or by the Office in a pending reexamination or supplemental examination of the '792 patent.

Accordingly, Ball et al raises an SNQ with respect to claims 1-2. Since each of claims 5, 6, 24, 25, 26 and 34 incorporate the subject matter of claims 1 or 2 by reference, an SNQ is additionally raised by Ball et al for this set of dependent claims.

SNQ #5: Does Broniak et al and Palayur and Ball et al taken together raise an SNQ in view of claims 1, 2, 5, 6, 10, 13, 17, 24, 25, 26, 31 and 34 of US Patent 9,749,792?

Each of Broniak et al and Palayur and Ball et al have been individually demonstrated herein to raise an SNQ with respect to independent claims 1 and 2 (SNQs #1, #2 and #4). Accordingly, the combination of the three references will equally raise an SNQ with respect to claims 1 and 2.

Since each of claims 5, 6, 10, 13, 17, 24, 25, 26, 31 and 34 further incorporate the subject matter of claims 1 or 2 by reference, an SNQ is additionally raised by the combination of Broniak et al and Palayur and Ball et al for this set of dependent claims.

SNQ #6: Does Broniak et al and Palayur and Ball et al and Petite et al taken together raise an SNQ in view of claims 1, 2, 5, 6, 10, 13, 17, 24, 25, 26, 31 and 34 of US Patent 9,749,792?

Each of Broniak et al and Palayur and Ball et al have been individually demonstrated herein to raise an SNQ with respect to independent claims 1 and 2 (SNQs #1, #2 and #4). Accordingly, the combination of the three references with an additional fourth reference (Petite et al) will contain the necessary teachings to raise an SNQ with respect to claims 1 and 2.

Since each of claims 5, 6, 10, 13, 17, 24, 25, 26, 31 and 34 further incorporate the subject matter of claims 1 or 2 by reference, an SNQ is additionally raised by the combination of Broniak et al and Palayur and Ball et al and Petite et al for this set of dependent claims.

SNQ #7: Does Broniak et al and Palayur and Ball et al and Caise et al taken together raise an SNQ in view of claims 1, 2, 5, 6, 10, 13, 17, 24, 25, 26, 31 and 34 of US Patent 9,749,792?

Each of Broniak et al and Palayur and Ball et al have been individually demonstrated herein to raise an SNQ with respect to independent claims 1 and 2 (SNQs #1, #2 and #4). Accordingly, the combination of the three references with an additional fourth reference (Caise et al) will contain the necessary teachings to raise an SNQ with respect to claims 1 and 2.

Since each of claims 5, 6, 10, 13, 17, 24, 25, 26, 31 and 34 further incorporate the subject matter of claims 1 or 2 by reference, an SNQ is additionally raised by the combination of Broniak et al and Palayur and Ball et al and Caise et al for this set of dependent claims.

SNQ #8: Does Broniak et al and Palayur and Ball et al and Vincent et al taken together raise an SNQ in view of claims 1, 2, 5, 6, 10, 13, 17, 24, 25, 26, 31 and 34 of US Patent 9,749,792?

Each of Broniak et al and Palayur and Ball et al have been individually demonstrated herein to raise an SNQ with respect to independent claims 1 and 2 (SNQs #1, #2 and #4). Accordingly, the combination of the three references with an additional fourth reference (Vincent et al) will contain the necessary teachings to raise an SNQ with respect to claims 1 and 2.

Since each of claims 5, 6, 10, 13, 17, 24, 25, 26, 31 and 34 further incorporate the subject matter of claims 1 or 2 by reference, an SNQ is additionally raised by the combination of Broniak et al and Palayur and Ball et al and Vincent et al for this set of dependent claims.

SNQ #9: Does Benson et al raises an SNQ in view of claims 1, 2, 4, 5, 6, 24, 25, 26 and 34 of US Patent 9,749,792?

Although Benson et al does teach a radio transceiver that may generally correspond to a base station, it does not teach that such base station would be "***mesh enabled***" as recited in in claim 1-2 of US Patent 9,749,792. Additionally, this reference does not teach "*an access point that transfers said water flow, water energy or water quality data…to an internet connection*" as set forth in claims 1-2 of US Patent 9,749,792.

Accordingly, there is not a substantial likelihood that a reasonable examiner would consider the Benson et al patent important in deciding whether or not claims 1-2 of US Patent 9,749,792 are patentable. For dependent claims 4, 5, 6, 24, 25, 26 and 34 of US Patent 9,749,792, there is not a substantial likelihood that a reasonable examiner would consider the Benson et al patent important in deciding the patentability of these claims.

SNQ #10: Does Blackwell et al ('804) raises an SNQ in view of claims 1, 2, 4, 5, 6, 24, 25, 26 and 34 of US Patent 9,749,792?

FIG 1 of Blackwell ('804) illustrates a "utility meter RF transmitter 12" which is controllable via a web page accessed by a customer through a web server 11. Accordingly, the

"utility meter RF transmitter 12" corresponds to a "*base station*" as set forth in claims 1-2 of the '792 patent.

As further seen from FIG 1, the utility meter transmitter 12 is configured to communicate with a gateway radio receiver 15 that in turn communicates with network servers and the Internet. Thus each utility meter transmitter 12 is capable of communicating with multiple communication devices within the overall network, corresponding generally with the "*mesh network*" as set forth in claims 1-2 of US Patent 9,749,792.

Referring to FIG 2 of Blackwell ('804), a data record is created with a time stamp 31, header 32, status 34 and a meter reading 35. This record filled with data collected from the meter and then transmitted from the utility meter transmitter 12 to the radio receiver gateway 15, which serves as an access point to the Internet for the utility meter transmitters 12. This functionality at the gateway 15 thus generally corresponds to "*an access point that transfers said water flow, water energy or water quality data…to an internet connection*".

There is a substantial likelihood that a reasonable examiner would consider the Blackwell et al ('804) patent important in deciding whether or not claims 1-2 of US Patent 9,749,792 are patentable. The same question of patentability has not already been decided as to the claim in a final holding of invalidity by a federal court or by the Office in an earlier concluded examination or review of the '792 patent. The same question of patentability has not been raised to or by the Office in a pending reexamination or supplemental examination of the '792 patent.

Accordingly, Blackwell et al ('804) raises an SNQ with respect to claims 1-2. Since each of claims 4, 5, 6, 24, 25, 26 and 34 incorporate the subject matter of claims 1 or 2 by reference, an SNQ is additionally raised by Blackwell et al ('804) for this set of dependent claims.

SNQ #11: Does Olson et al ('690) raises an SNQ in view of claims 1, 2, 4, 5, 6, 24, 25, 26 and 34 of US Patent 9,749,792?

Although Olson et al ('690) does teach a radio transceiver that may generally correspond to a base station (FIG 3: structures 16 and 24), it does not teach that such base station would be "*mesh enabled*" as recited in in claim 1-2 of US Patent 9,749,792. Additionally, this reference does not teach "*an access point that transfers said water flow, water energy or water quality data…to an internet connection*" as set forth in claims 1-2 of US Patent 9,749,792.

Accordingly, there is not a substantial likelihood that a reasonable examiner would consider the Olson et al ('690) patent important in deciding whether or not claims 1-2 of US Patent 9,749,792 are patentable. For dependent claims 4, 5, 6, 24, 25, 26 and 34 of US Patent 9,749,792, there is not a substantial likelihood that a reasonable examiner would consider the Olson et al ('690) patent important in deciding the patentability of these claims.

SNQ #12: Does Zigdon et al ('546) raises an SNQ in view of claims 1, 2, 4, 5, 6, 24, 25, 26 and 34 of US Patent 9,749,792?

FIG 1 of Zigdon ('546) illustrate explicit base stations 14, each of which correspond to the "*base station*" as set forth in claims 1-2 of the '792 patent.

Each base station communicates with a utility meter 12, data operations center 16, database 25 and downlink 20 to an external network. Thus each base station 14 is capable of communicating with multiple communication devices within the overall network, corresponding generally with the "*mesh network*" as set forth in claims 1-2 of US Patent 9,749,792.

The data operations center 16 in FIG 1 accesses data from the database 25 and transfers this data to the downlink 20 leading to external networks, including the Internet (col. 8, lines 35-38). The data collected in the database 25 includes water metering data (col. 3, line 42). The data

operations center 16 in FIG 1 thus generally corresponds to *an "access point that transfers said water flow, water energy or water quality data…to an internet connection"*.

There is a substantial likelihood that a reasonable examiner would consider the Zigdon ('546) patent important in deciding whether or not claims 1-2 of US Patent 9,749,792 are patentable. The same question of patentability has not already been decided as to the claim in a final holding of invalidity by a federal court or by the Office in an earlier concluded examination or review of the '792 patent. The same question of patentability has not been raised to or by the Office in a pending reexamination or supplemental examination of the '792 patent.

Accordingly, Zigdon ('546) raises an SNQ with respect to claims 1-2. Since each of claims 4, 5, 6, 24, 25, 26 and 34 incorporate the subject matter of claims 1 or 2 by reference, an SNQ is additionally raised by Zigdon ('546) for this set of dependent claims.

SNQ #13: Does Zigdon et al ('651) raises an SNQ in view of claims 1, 2, 4, 5, 6, 24, 25, 26 and 34 of US Patent 9,749,792?

FIG 1 of Zigdon ('651) illustrate explicit base stations 14, each of which correspond to the "*base station*" as set forth in claims 1-2 of the '792 patent.

Each base station communicates with a utility meter 12, data operations center 16, database 25 and downlink 20 to an external network. Thus each base station 14 is capable of communicating with multiple communication devices within the overall network, corresponding generally with the "*mesh network*" as set forth in claims 1-2 of US Patent 9,749,792.

The data operations center 16 in FIG 1 accesses data from the database 25 and transfers this data to the downlink 20 leading to external networks, including the Internet (col. 8, line 31333). The data collected in the database 25 includes water metering data (col. 3, line 37). The data

operations center 16 in FIG 1 thus generally corresponds to *an "access point that transfers said water flow, water energy or water quality data…to an internet connection"*.

There is a substantial likelihood that a reasonable examiner would consider the Zigdon ('651) patent important in deciding whether or not claims 1-2 of US Patent 9,749,792 are patentable. The same question of patentability has not already been decided as to the claim in a final holding of invalidity by a federal court or by the Office in an earlier concluded examination or review of the '792 patent. The same question of patentability has not been raised to or by the Office in a pending reexamination or supplemental examination of the '792 patent.

Accordingly, Zigdon ('651) raises an SNQ with respect to claims 1-2. Since each of claims 4, 5, 6, 24, 25, 26 and 34 incorporate the subject matter of claims 1 or 2 by reference, an SNQ is additionally raised by Zigdon ('651) for this set of dependent claims.

SNQ #14: Does Lazar raises an SNQ in view of claims 1, 2, 4, 5, 6, 24, 25, 26 and 34 of US Patent 9,749,792?

Although Lazar does teach a radio transceiver that may generally correspond to a base station (FIG 1: transmitter 10), it does not teach that such base station would be "***mesh enabled***" as recited in in claim 1-2 of US Patent 9,749,792. Additionally, this reference does not teach "*an access point that transfers said water flow, water energy or water quality data…to an internet connection*" as set forth in claims 1-2 of US Patent 9,749,792.

Accordingly, there is not a substantial likelihood that a reasonable examiner would consider the Lazar patent important in deciding whether or not claims 1-2 of US Patent 9,749,792 are patentable. For dependent claims 4, 5, 6, 24, 25, 26 and 34 of US Patent 9,749,792, there is not a substantial likelihood that a reasonable examiner would consider the Lazar patent important in deciding the patentability of these claims.

SNQ #15: Does Sanderford, Jr raises an SNQ in view of claims 1, 2, 4, 5, 6, 24, 25, 26 and 34 of US Patent 9,749,792?

Sanderford Jr at FIG 1 teaches utility meters 12 equipped with transmitters so as to transmit signal to a network cloud 22. Each transmitting utility meter generally corresponds to a "*base station*" as set forth in claims 1-2 of the '792 patent.

Certain utility meters 12 are capable of transmitting to intermediate utility meters 18. The intermediate utility meters 18 in turn are capable of transmitting to multiple gateways 16. This arrangement allows for a mesh network at the intermediate meter layer and gateway layer of the overall network. This architecture generally corresponds with the "*mesh network*" as set forth in claims 1-2 of US Patent 9,749,792.

FIG 1 further teaches a data repeater 24 at the layer of the intermediate meter 18. The repeater will re-transit water meter data (col. 2, line 16) collected at the meters 12 to the gateways 16 of public network 22. The public network 22 is the Internet (col. 5, line 62). Accordingly, the repeater 24 generally corresponds with "*an access point that transfers said water flow, water energy or water quality data…to an internet connection*".

There is a substantial likelihood that a reasonable examiner would consider the Sanderford, Jr patent important in deciding whether or not claims 1-2 of US Patent 9,749,792 are patentable. The same question of patentability has not already been decided as to the claim in a final holding of invalidity by a federal court or by the Office in an earlier concluded examination or review of the '792 patent. The same question of patentability has not been raised to or by the Office in a pending reexamination or supplemental examination of the '792 patent.

Accordingly, Sanderford, Jr raises an SNQ with respect to claims 1-2. Since each of claims 4, 5, 6, 24, 25, 26 and 34 incorporate the subject matter of claims 1 or 2 by reference, an SNQ is additionally raised by Sanderford, Jr for this set of dependent claims.

SNQ #16: Does Olson et al ('093) raises an SNQ in view of claims 1, 2, 4, 5, 6, 24, 25, 26 and 34 of US Patent 9,749,792?

Although Olson et al ('093) does teach a radio transceiver that may generally correspond to a base station (FIG 3: structures 16 and 24), it does not teach that such base station would be "***mesh enabled***" as recited in in claim 1-2 of US Patent 9,749,792. Additionally, this reference does not teach "*an access point that transfers said water flow, water energy or water quality data...to an internet connection*" as set forth in claims 1-2 of US Patent 9,749,792.

Accordingly, there is not a substantial likelihood that a reasonable examiner would consider the Olson et al ('093) patent important in deciding whether or not claims 1-2 of US Patent 9,749,792 are patentable. For dependent claims 4, 5, 6, 24, 25, 26 and 34 of US Patent 9,749,792, there is not a substantial likelihood that a reasonable examiner would consider the Olson et al ('093) patent important in deciding the patentability of these claims.

SNQ #17: Does Blackwell et al ('421) raises an SNQ in view of claims 1, 2, 4, 5, 6, 24, 25, 26 and 34 of US Patent 9,749,792?

FIG 1 of Blackwell ('421) illustrates a "utility meter RF transmitter 12" which is controllable via a web page accessed by a customer through a web server 11. Accordingly, the "utility meter RF transmitter 12" corresponds to a "*base station*" as set forth in claims 1-2 of the '792 patent.

As further seen from FIG 1, the utility meter transmitter 12 is configured to communicate with a gateway radio receiver 15 that in turn communicates with network servers and the Internet.

Thus each utility meter transmitter 12 is capable of communicating with multiple communication devices within the overall network, corresponding generally with the "*mesh network*" as set forth in claims 1-2 of US Patent 9,749,792.

Referring to FIG 2 of Blackwell ('421), a data record is created with a time stamp 31, header 32, status 34 and a meter reading 35. This record filled with data collected from the meter and then transmitted from the utility meter transmitter 12 to the radio receiver gateway 15, which serves as an access point to the Internet for the utility meter transmitters 12. This functionality at the gateway 15 thus generally corresponds to "*an access point that transfers said water flow, water energy or water quality data…to an internet connection*".

There is a substantial likelihood that a reasonable examiner would consider the Blackwell et al ('421) patent important in deciding whether or not claims 1-2 of US Patent 9,749,792 are patentable. The same question of patentability has not already been decided as to the claim in a final holding of invalidity by a federal court or by the Office in an earlier concluded examination or review of the '792 patent. The same question of patentability has not been raised to or by the Office in a pending reexamination or supplemental examination of the '792 patent.

Accordingly, Blackwell et al ('421) raises an SNQ with respect to claims 1-2. Since each of claims 4, 5, 6, 24, 25, 26 and 34 incorporate the subject matter of claims 1 or 2 by reference, an SNQ is additionally raised by Blackwell et al ('421) for this set of dependent claims.

Service of Papers

After filing of a request for ex parte reexamination by a third party requester, any document filed by either the patent owner or the third party requester must be served on the other party (or parties where two or more third party requester proceedings are merged) in the reexamination proceeding in the manner provided in 37 CFR 1.248. The document must reflect service or the document may be refused consideration by the Office. See 37 CFR 1.550(f).

Extensions of Time

Extensions of time under 37 CFR 1.136(a) will not be permitted in these proceedings because the provisions of 37 CFR 1.136 apply only to "an applicant" and not to parties in a reexamination proceeding. Additionally, 35 U.S.C. 305 requires that ex parte reexamination proceedings "will be conducted with special dispatch" (37 CFR 1.550(a)). Extensions of time in ex parte reexamination proceedings are provided for in 37 CFR 1.550(c).

Litigation Reminder

The patent owner is reminded of the continuing responsibility under 37 CFR 1.565(a) to apprise the Office of any litigation activity, or other prior or concurrent proceeding, involving US Patent 9,749,792 throughout the course of this reexamination proceeding. The third party requester is also reminded of the ability to similarly apprise the Office of any such activity or proceeding throughout the course of this reexamination proceeding. See MPEP §§ 2207, 2282 and 2286.

Conclusion

Claims 1-34 are requested for reexamination. Claims 1-34 will be subject to reexamination in this proceeding.

Correspondence

All correspondence relating to this *ex parte* reexamination proceeding should be directed as follows:

By **U.S. Postal Service Mail** to:

Mail Stop *Ex Parte* Reexam
ATTN: Central Reexamination Unit
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

By FAX to: (571) 273-9900
Central Reexamination Unit

By hand to: Customer Service Window
Randolph Building
401 Dulany St.
Alexandria, VA 22314

Any inquiry concerning this communication or earlier communications from the Reexamination Legal Advisor or Examiner, or as to the status of this proceeding, should be directed to the Central Reexamination Unit at telephone number (571) 272-7705.

/SAMUEL G RIMELL/
Primary Examiner, Art Unit 3992

Conferees:

/ANGELA M LIE/
Primary Examiner, Art Unit 3992

/ALEXANDER J KOSOWSKI/
Supervisory Patent Examiner, Art Unit 3992

Reexamination	Application/Control No.	Applicant(s)/Patent Under Reexamination
	90/014,355	9749792
	Certificate Date	Certificate Number

Requester Correspondence Address: ☑ **Patent Owner** ☐ **Third Party**

Michael E Klicpera
P.O. Box 573
La Jolla, CA 92038-0573

LITIGATION REVIEW ☑	/SR/ (examiner initials)	23 September 2019 (date)
Case Name		Director Initials

COPENDING OFFICE PROCEEDINGS	
TYPE OF PROCEEDING	NUMBER

Search Notes	Application/Control No. 90/014,355	Applicant(s)/Patent Under Reexamination 9749792
	Examiner SAM RIMELL	Art Unit 3992

CPC - Searched*		
Symbol	Date	Examiner

CPC Combination Sets - Searched*		
Symbol	Date	Examiner

US Classification - Searched*			
Class	Subclass	Date	Examiner

* See search history printout included with this form or the SEARCH NOTES box below to determine the scope of the search.

Search Notes		
Search Notes	Date	Examiner
Reviewed prosecution history of US Patent 9,749,792	09/23/2019	/SR/

Interference Search			
US Class/CPC Symbol	US Subclass/CPC Group	Date	Examiner

Doc code: IDS
Doc description: Information Disclosure Statement (IDS) Filed

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	14596460
	Filing Date	2015-01-14
	First Named Inventor	KLICPERA
	Art Unit	3753
	Examiner Name	JELLETT
	Attorney Docket Number	70965.01

U.S.PATENTS

Examiner Initial*	Cite No	Patent Number	Kind Code1	Issue Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
/S.G.R/	1	8833390	B2	2014-09-16	BALL	Fig. 1-2, 11, 23, 29, and 31, Col. 3, lines 17-67,Col. 4, lines 1-31, Col. 8, lines 20-32, Col. 111 lines 7-28, Col. 12, lines 23-42, Col. 16, lines 17-67, Col. 17, lines 1-44
/S.G.R/	2	9253754	B2	2016-02-02	SANDERFORD	Fig. 2 and 4, Col. 7, lines 2-67, Col. 9, lines 65-67, Col. 10, lines 1-43
/S.G.R/	3	6539968	B1	2003-04-01	WHITE	Fig. 4 and 6, Col. 2, lines 43-51, Col. 5, lines 35-50, Claim 1
/S.G.R/	4	5660198		1997-08-26	McCLARAN	Fig. 1, Col. lines 35-49, Col. 2, lines 15-25, 55-60, Col. 3, lines 10-40
/S.G.R/	5	5636653		1997-06-10	TITUS	Fig. 2 and 16, Col. 2, lines 35-67, Col. 3, lines 1-3, Col. 4, lines 38-67, Col. 5, lines 1-67, Col. 6, lines 1-53, Col. 12, lines 42-60
/S.G.R/	6	6105607	B2	2000-08-22	CAISE	Fig. 7, Col. 3, lines 33-67. Col. 5, lines 53-56
/S.G.R/	7	6543479	B2	2003-04-08	COFFEY	Fig. 2, 4, and 5, Col. 2, lines 14-67, Col. 3, lines 38-56
/S.G.R/	8	9019120	B2	2015-04-28	BRONIAK	Fig. 1, 2, and 3, Col. 3, lines 1-19, 52-67, Col. 4, lines 1-37, 56-63, Col. 5 lines 1-67

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)	Application Number	14596460
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	Art Unit	3753
	Examiner Name	JELLETT
	Attorney Docket Number	70965.01

/S.G.R/	9	4949976		1990-07-10	GASTOUNIOTIS	Fig. 1, Col. 3 lines 7-67, Col. 3 lines 40-65
/S.G.R/	10	5298894		1994-03-29	CERNY	Fig. 2, 3, and 5, Col. 3 lines 6-52
/S.G.R/	11	8539827	B2	2012-08-02	BENSON	Fig. 1, Col. 1 lines 45-48, Col.2 lines 47-57, 61-64, Col. 3 lines 3-4, 17-30, 64-67
/S.G.R/	12	8644804	B2	2011-04-07	BLACKWELL	Col. 1 lines 7-10, 53-55, Col. 2 lines 31-33, 51-85. Col. 2 lines 63-76, Col. 3 lines 1-11
/S.G.R/	13	8878690	B2	2010-12-23	OLSON	Fig. 2, 3, 4, and 5, Col. 1 lines 61-62, Col. 4 lines 3-8, 43-60, Col. 3, lines 22-25
/S.G.R/	14	7012546	B1	2002-07-02	ZIGDON	Col. 5 lines 33-43, Col. 7 lines 12-19, 36-40, Col. 8, lines 35-38, Col. 10 lines 14-18
/S.G.R/	15	8269651	B2	2006-11-02	ZIGDON	Col. 4 lines 46-58, Col. 5, lines 39-43, Col. 7 lines 2-6, 24-29, 36-40, Col. 8 lines 25-28,Col. 9 lines 66-67, Col. 10 lines 1-3, Col. 16 lines 47-49
/S.G.R/	16	7626511	B2	2007-12-13	LAZAR	Col. 1 lines 104, Col. 3 lines 2-6, 21-26, 37-42, 54,60
/S.G.R/	17	7605717	B2	2009-10-20	OLSON	Col. 2, lines 38-60, Col. lines 1-50, Col. 3 lines 1-14
/S.G.R/	18	8217804	B2	2012-07-10	LAUGHLIN-PARKER	Col. 1, lines 14-60, Col. 3 lines 24-67
/S.G.R/	19	8625722	B2	2014-01-07	ROUQUETTE	Col. 3 lines 5-50, Col. 6, lines 41-50, Col. 7 lines 17-47, Col. 8 lines 59-67, Col. 14, lines 32-43

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/S.G.R/	20	9253754	B2	2016-02-02	SANDERFORD	Fog. 1, 4, Col. 5, lines 60-65, Col. 8 lines 21-26, Col. 10 lines 22-35
/S.G.R/	21	9417093	B2	2016-08-16	OLSON	Fig. 1, 3, 4, and 5, Col. 3 lines 44-67, Col. 4 lines 11-50
/S.G.R/	22	9709421	B2	2017-07-18	BLACKWELL	Fig. 1, Col. 1 lines 46-67, Col. 3 lines 1-17, 25-67, Col. 4, lines 1-20
/S.G.R/	23	8602384	B2	2013-12-10	WILLIAMSON	Fig. 1, Col. 2, lines 44-57
/S.G.R/	24	5971011		1999-10-26	PRICE	Abstract, Col. 2, line 7-67, Col. 4, lines 7-28

If you wish to add additional U.S. Patent citation information please click the Add button.

U.S.PATENT APPLICATION PUBLICATIONS

Examiner Initial*	Cite No	Publication Number	Kind Code[1]	Publication Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
/S.G.R/	1	20040193329	A1	2004-09-30	RANSOM	Paragraphs 107, 110, 116, 118-123, 124-125, 127, 129, 133, 143, 144-145, 150, 162, 163-164, 166-167, 168, 173-174, 194.
/S.G.R/	2	20080149180	A1	2008-06-26	PARRIS	Fig. 1, 7, 8,15 and 16, Paragraphs 96, 99, 109, 117, 121, 123, 141, 151, 156, 159-163, 171-173, 205, 212 220-221
/S.G.R/	3	20080295895	A1	2008-12-04	VINCENT	Paragraphs 1, 10, 11, 13, 14
/S.G.R/	4	20110035063	A1	2011-02-10	PALAYUR	Fig. 1-10, 14, 16-17, Paragraphs 8, 15, 16, 22-25, 36, 40, 69, 75, 80, 84, 91

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INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
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	Filing Date	2015-01-14
	First Named Inventor	KLICPERA
	Art Unit	3753
	Examiner Name	JELLETT
	Attorney Docket Number	70965.01

FOREIGN PATENT DOCUMENTS

Examiner Initial*	Cite No	Foreign Document Number[3]	Country Code[2] i	Kind Code[4]	Publication Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear	T[5]
	1							☐

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NON-PATENT LITERATURE DOCUMENTS

Examiner Initials*	Cite No	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc), date, pages(s), volume-issue number(s), publisher, city and/or country where published.	T[5]
	1		☐

If you wish to add additional non-patent literature document citation information please click the Add button

EXAMINER SIGNATURE

Examiner Signature	/SAMUEL G RIMELL/	Date Considered	09/16/2019

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through a citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

[1] See Kind Codes of USPTO Patent Documents at www.USPTO.GOV or MPEP 901.04. [2] Enter office that issued the document, by the two-letter code (WIPO Standard ST.3). [3] For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. [4] Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. [5] Applicant is to place a check mark here if English language translation is attached.

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	14596460
	Filing Date	2015-01-14
	First Named Inventor	KLICPERA
	Art Unit	3753
	Examiner Name	JELLETT
	Attorney Docket Number	70965.01

CERTIFICATION STATEMENT

Please see 37 CFR 1.97 and 1.98 to make the appropriate selection(s):

☒ That each item of information contained in the information disclosure statement was first cited in any communication from a foreign patent office in a counterpart foreign application not more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(1).

OR

☐ That no item of information contained in the information disclosure statement was cited in a communication from a foreign patent office in a counterpart foreign application, and, to the knowledge of the person signing the certification after making reasonable inquiry, no item of information contained in the information disclosure statement was known to any individual designated in 37 CFR 1.56(c) more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(2).

☐ See attached certification statement.

☐ The fee set forth in 37 CFR 1.17 (p) has been submitted herewith.

☐ A certification statement is not submitted herewith.

SIGNATURE

A signature of the applicant or representative is required in accordance with CFR 1.33, 10.18. Please see CFR 1.4(d) for the form of the signature.

Signature	/Michael Edward Klicpera	Date (YYYY-MM-DD)	2019-08-03
Name/Print	Michael Edward Klicpera	Registration Number	38044

Privacy Act Statement

The Privacy Act of 1974 (P.L. 93-579) requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C. 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether the Freedom of Information Act requires disclosure of these record s.

2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.

3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.

4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).

5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.

6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).

7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.

8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspections or an issued patent.

9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

Litigation Search Report OCRU

CONTROL No. 90/014,355

To: RIMELL, Samuel Location: Central Reexam Unit Art Unit: 3992 Date: 8/27/19 Case Serial Number: 90/014,355	**From: Monica A. Graves** **Location: OCRU, REM 4B76** **Phone: (571) 272-7253** **monica.graves@uspto.gov**

Search Notes

Litigation search for U.S. Patent Number – **9,749,792**

No Litigation Found

1) I performed a KeyCite Search in Westlaw, which retrieves all history on the patent including any litigation.

2) I performed a search on the patent in Lexis CourtLink for any open dockets or closed cases.

3) I performed a search in Lexis in the Federal Courts and Administrative Materials databases for any cases found.

4) I performed a search in Lexis in the IP Journal and Periodicals database for any articles on the patent.

5) I performed a search in Lexis in the news databases for any articles about the patent or any articles about litigation on this patent.

Citing References (10)

Treatment	Title	Date	Type	Depth	Headnote(s)
Mentioned by	**1. Water use monitoring apparatus** LitAlert P2018-44-05 ... 26/2018 Subsequent Action: 10/26/2018 Action Taken: CAUSE - 35 USC 271 - COMPLAINT FOR PATENT INFRINGEMENT Notes: none Other Patents: US 9297150 US 9494480 US 9749792 Other Trademarks: none See LitAlert No: none ...	Oct. 26, 2018	Lit Alert		—
Mentioned by	**2. Water use monitoring apparatus** LitAlert P2018-44-06 ... Date: 10/26/2018 Subsequent Action: 10/26/2018 Action Taken: CAUSE - 35 USC 271 - COMPLAINT FOR PATENT INFRINGEMENT Notes: none Other Patents: US 9297150 US 9749792 Other Trademarks: none See LitAlert No: none ...	Oct. 26, 2018	Lit Alert		—
Mentioned by	**3. Water use monitoring apparatus** LitAlert P2018-44-07 ... 26/2018 Subsequent Action: 10/26/2018 Action Taken: CAUSE - 35 USC 271 - COMPLAINT FOR PATENT INFRINGEMENT Notes: none Other Patents: US 9297150 US 9494480 US 9749792 Other Trademarks: none See LitAlert No: none ...	Oct. 26, 2018	Lit Alert		—
—	**4. WATER PARAMETER USE AND MONITORING APPARATUS, HAS BASE STATION FUNCTIONS AS MESH-ENABLED DEVICE AND COMBINATION FUNCTION AS SIGNAL REPEATERS FOR RELAYING DATA TO ACCESS POINT USING ENCRYPTION AND IDENTIFICATION TECHNOLOGY** Out Of Plan DWPI 2016-169164 ... repeaters for relaying water parameter data to an a particular access point using encryption and identification technology.First Derwent Appearance:2016.21 Publication No. (Derwent): US 9749792 B2 Original Title (English):WATER USE MONITORING APPARATUS Publication Date:2017-08-29 Application No.:US 596460 Application Date:2015-01-14 Inventor(s ...	Aug. 11, 2009	DWPI	—	—
—	**5. RF 047325/0670** Out Of Plan ... App. 20150204701 Published Application Date 2015-07-23 Application Number 14/561271 Application Date 2014-12-05 Title Water Use Monitoring Apparatus Granted Patent Number US Pat. 9749792 Granted Patent Date 2017-08-29 Published Application Number US Pat. App. 20160076909 Published Application Date 2016-03-17 Application Number 14/596460 ...	Oct. 26, 2018	Assignments	—	—
—	**6. Rein Tech, Inc. v. Mueller Water Products, Inc.**	Oct. 26, 2018	Docket Summaries	—	—
—	**7. Rein Tech, Inc. v. Flo Technologies, Inc.**	Oct. 26, 2018	Docket Summaries	—	—
—	**8. Rein Tech, Inc. v. Xylem, Inc.**	Oct. 26, 2018	Docket Summaries	—	—

Treatment	Title	Date	Type	Depth	Headnote(s)
—	**9. SYSTEMS AND METHODS FOR SYSTEMIC RESOURCE UTILIZATION ANALYSIS AND MANAGEMENT** Out Of Plan US PAT 10282966 , U.S. PTO Utility Systems, methods, and articles of manufacture provide for systemic resource utilization analysis and management, such as employing a single-point sensor to detect or identify... ... US US 9383289 2016/07 Meyer US US 9494480 2016/11 Klicpera US US 9692538 2017/06 Tyson US US 9713084 2017/07 Skeoch US US 9749792 2017/08 Klicpera US US 9857805 2018/01 Halimi US US 2008/0291855 2008/11 Bata 370/311 US US 2010/0076835 2010/03 ...	May 07, 2019	Patents	—	—
—	**10. METHOD AND APPARATUS TO MONITOR AND CONTROL A WATER SYSTEM** Out Of Plan US PAT 10273165 , U.S. PTO Utility A system for providing treated water includes a water treatment unit including an inlet water quality probe, a worker bed, a probe to measure a parameter of water from the worker... ... 9100728 2015/08 Higgins et al.US US 9460596 2016/10 Moses US US 9485530 2016/11 Diachenko US US 9494480 2016/11 Klicpera US US 9749792 2017/08 Klicpera US US 9769420 2017/09 Moses US US 9945103 2018/04 Thompson et al.US US 9981868 2018/05 Raymont US ...	Apr. 30, 2019	Patents	—	—

EXHIBIT 3

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Dockets (3) Sort by: Relevance

1. 1:18cv1682. Rein Tech, Inc. V. Flo Technologies, Inc.

Delaware District Court | Oct 26, 2018 | 1:18cv1682 | Closed
... Trademarks for Patent/Trademark Number(s) US 8,347,427 B2; US 9,297,150 B2; US **9,749,792** B2; US 9,494,480 B2. (ceg) (Entered: 10/26/2018) 5150389920 2019-08-05 Report to ...
... Trademarks for Patent/Trademark Number(s) US 8,347,427 B2; US 9,297,150 B2; US **9,749,792** B2; US 9,494,480 B2. (ceg) (Entered: 10/26/2018) ...
... 2016-03-29 1 1 9,494,480 Water use monitoring apparatus 2016-11-15 1 1 **9,749,792** Water use monitoring apparatus 2017-08-29 1 1...

2. 1:18cv1683. Rein Tech, Inc. V. Mueller Systems, Llc

Delaware District Court | Oct 26, 2018 | 1:18cv1683 | Open
... Trademarks for Patent/Trademark Number(s) US 8,347,427 B2; US 9,297,150 B2; US **9,749,792** B2. (ceg) (Entered: 10/26/2018) 5150383614 2019-08-05 Report to the Commissioner of ...
... Trademarks for Patent/Trademark Number(s) US 8,347,427 B2; US 9,297,150 B2; US **9,749,792** B2. (ceg) (Entered: 10/26/2018) ...
... use monitoring apparatus and water damage prevention system 2016-03-29 1 1 **9,749,792** Water use monitoring apparatus 2017-08-29 1 1...

3. 1:18cv1684. Rein Tech, Inc. V. Xylem, Inc.

Delaware District Court | Oct 26, 2018 | 1:18cv1684 | Closed
... Trademarks for Patent/Trademark Number(s) US 8,347,427 B2; US 9,297,150 B2; US **9,749,792** B2; US 9,494,480 B2. (ceg) (Entered: 10/26/2018) 5150390625 2019-08-05 Report to ...
... Trademarks for Patent/Trademark Number(s) US 8,347,427 B2; US 9,297,150 B2; US **9,749,792** B2; US 9,494,480 B2. (ceg) (Entered: 10/26/2018)...
... 2016-03-29 1 1 9,494,480 Water use monitoring apparatus 2016-11-15 1 1 **9,749,792** Water use monitoring apparatus 2017-08-29 1 1...

Content type: Dockets
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Search Type: Boolean - Fewer Results
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Results for: US PAT 9749792 or 9,749,792

News (5) Sort by: Relevance

1. Head Line: US Patent granted to Klicpera, Michael Edward (California) on August 29, 2017 titled as "Water use monitoring apparatus"

   Plus Patent News | Aug 31, 2017 | 213 words
   ... United States Patent and Trademark Office has granted patent no. **9,749,792** on August 29, 2017, to Klicpera; Michael Edward (California) ...

2. U.S. Patent and Trademark Office Awards Patent for Water Use Monitoring Apparatus

   Global IP News. Electronics Patent News | Aug 29, 2017 | 411 words
   ... Name: Electronics Patent News Patent Application Number: 14/596,460 Patent Publication Number: **9,749,792** International Patent Classification Codes: H04W 4/021 (20130101), E03B 7/071 (20130101), F16K ...

3. US Patent Issued on Aug. 29 for "Water use monitoring apparatus" (California Inventor)

   US Fed News | Aug 30, 2017 | 254 words
   ... ALEXANDRIA , Va. , Aug. 30 -- United States Patent no. **9,749,792** , issued on Aug. 29, "Water use monitoring apparatus" was invented ...

4. 39 usinas vendem energia eólica no leilão A-5

   AE Conjuntura e Finanças | Dec 20, 2011 | COFI | 269 words
   ... Norte e que somam 120 MW de capacidade instalada. Juntos comercializaram **9.749.792** MWh . Além dos projetos eólicos, duas térmicas a biomassa também ...

5. Market Maker Surveillance Report. PFE, DRYS, WFC, ILMN, ORCL, EVCA, Bearishly Biased Price Friction For Tuesday, February 15th 2011

   M2 PressWIRE | Feb 16, 2011 | 2283 words
   ... 7,293,694 60.27% 5,132,808 42.41% 2,161,066 Abnormal WFC $-0.240 -0.71% 11,819,948 49.03% **9,749,792** 40.45% 2,070,156 Abnormal ILMN $-1.860 -2.55% 2,633,290 80.02% 635,345 19.31% 1,997,945 ...

Content type: News
Terms: US PAT 9749792 or 9,749,792
Search Type: Boolean - Fewer Results
Narrow By: Sources: News
Date and Time: Aug 07, 2019 10:41:01 p.m. EDT

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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
90/014,355	08/05/2019	9749792	70965.01	8459

22509 7590 08/26/2019
MICHAEL E. KLICPERA
PO BOX 573
LA JOLLA, CA 92038-0573

EXAMINER	
RIMELL, SAMUEL G	

ART UNIT	PAPER NUMBER
3992	

MAIL DATE	DELIVERY MODE
08/26/2019	PAPER

Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

PTOL-90A (Rev. 04/07)

Ex Parte Reexamination Interview Summary – Pilot Program for Waiver of Patent Owner's Statement	**Control No.** 90/014,355	**Patent Under Reexamination is Requested** 9749792	
	Examiner RIMELL, Samuel	**Art Unit** 3992	**AIA (FITF) Status** No

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address. --

All participants (USPTO official and patent owner):

(1) Michael Klicpera, Reg 38044 (3) _____

(2) Monica Graves, Paralegal (4) _____

Date of Telephonic Interview: 16 August 2019.

A. The USPTO official requested waiver of the patent owner's statement pursuant to the pilot program for waiver of patent owner's statement in *ex parte* reexamination proceedings.*

☐ The patent owner **agreed** to waive its right to file a patent owner's statement under 35 U.S.C. 304 in the event reexamination is ordered for the above-identified patent.

☐ The patent owner **did not agree** to waive its right to file a patent owner's statement under 35 U.S.C. 304 at this time.

☐ USPTO personnel were unable to reach the patent owner.**

B. The Patent Owner of record telephoned the Office and indicated they would like to participate in the pilot program for waiver of patent owner's statement in *ex parte* reexamination proceedings.*

☑ The Patent owner of record telephoned the Office and **agreed** to waive its right to file a patent owner's statement under 35 U.S.C. 304 in the event reexamination is ordered for the above-identified patent.

The patent owner is not required to file a written statement of this telephone communication under 37 CFR 1.560(b) or otherwise. However, any disagreement as to this interview summary must be brought to the immediate attention of the USPTO, and no later than one month from the mailing date of this interview summary. Extensions of time are governed by 37 CFR 1.550(c).

*For more information regarding this pilot program, see *Pilot Program for Waiver of Patent Owner's Statement in Ex Parte Reexamination Proceedings, 75 Fed. Reg.* 47269 (August 5, 2010), available on the USPTO Web site at http://www.uspto.gov/patents/law/notices/2010.jsp.

**The patent owner may contact the USPTO personnel at (571) 272-7705 or at the telephone number provided below if the patent owner decides to waive the right to file a patent owner's statement under 35 U.S.C. 304.

/MONICA A GRAVES/
Primary Examiner, OCRU (571)272-7253
Signature and telephone number of the USPTO official, who contacted, was contacted by, or attempted to contact the patent owner.

cc: Requester (if third party requester)

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REEXAM CONTROL NUMBER	FILING OR 371 (c) DATE	PATENT NUMBER
90/014,355	08/05/2019	9749792

CONFIRMATION NO. 8459

REEXAM ASSIGNMENT NOTICE

22509
MICHAEL E. KLICPERA
PO BOX 573
LA JOLLA, CA 92038-0573

OC000000110444019

Date Mailed: 08/15/2019

NOTICE OF ASSIGNMENT OF REEXAMINATION REQUEST

The above-identified request for reexamination has been assigned to Art Unit 3993. All future correspondence to the proceeding should be identified by the control number listed above and directed to the assigned Art Unit.

A copy of this Notice is being sent to the latest attorney or agent of record in the patent file or to all owners of record. (See 37 CFR 1.33(c)). If the addressee is not, or does not represent, the current owner, he or she is required to forward all communications regarding this proceeding to the current owner(s). An attorney or agent receiving this communication who does not represent the current owner(s) may wish to seek to withdraw pursuant to 37 CFR 1.36 in order to avoid receiving future communications. If the address of the current owner(s) is unknown, this communication should be returned within the request to withdraw pursuant to Section 1.36.

NOTICE OF USPTO EX PARTE REEXAMINATION PATENT OWNER STATEMENT WAIVER PROGRAM

The USPTO has implemented a pilot program where, after a reexamination proceeding has been granted a filing date and before the examiner begins his or her review, the patent owner may orally waive the right to file a patent owner's statement. See *"Pilot Program for Waiver of Patent Owner's Statement in Ex Parte Reexamination Proceedings,"* 75 FR 47269 (August 5, 2010). One goal of the pilot program is to reduce the pendency of reexamination proceedings and improve the efficiency of the reexamination process.

Ordinarily when ex parte reexamination is ordered, the USPTO must wait until after the receipt of the patent owner's statement and the third party requester's reply, or after the expiration of the time period for filing the statement and reply (a period that can be as long as 5 to 6 months), before mailing a first determination of patentability. The USPTO's first determination of patentability is usually a first Office action on the merits or a Notice of Intent to Issue Reexamination Certificate (NIRC).

Under the pilot program, the patent owner's oral waiver allows the USPTO to act on the first determination of patentability immediately after determining that reexamination will be ordered, and in a suitable case issue the reexamination order and the first determination of patentability (which could be a NIRC if the claims under reexamination are confirmed) at the same time.

Benefits to the Patent Owner for participating in this pilot program include reduction in pendency.

To participate in this pilot program, Patent Owners may contact the USPTO's Central Reexamination Unit (CRU) at 571-272-7705. The USPTO will make the oral waiver of record in the reexamination file in an interview summary and a copy will be mailed to the patent owner and any third party requester.

cc: Third Party Requester(if any)

,

/tplovelace/

Legal Instruments Examiner
Central Reexamination Unit 571-272-7705; FAX No. 571-273-9900

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REEXAM CONTROL NUMBER	FILING OR 371 (c) DATE	PATENT NUMBER
90/014,355	08/05/2019	9749792

CONFIRMATION NO. 8459

REEXAMINATION REQUEST NOTICE

22509
MICHAEL E. KLICPERA
PO BOX 573
LA JOLLA, CA 92038-0573

OC000000110444017

Date Mailed: 08/15/2019

NOTICE OF REEXAMINATION REQUEST FILING DATE

(Patent Owner Requester)

Requester is hereby notified that the filing date of the request for reexamination is 08/05/2019, the date the required fee was received. (See CFR 1.510(d)).

A decision on the request for reexamination will be mailed within three months from the filing date of the request for reexamination. (See 37 CFR 1.515(a)).

Pursuant to 37 CFR 1.33(c), future correspondence in this reexamination proceeding will be with the latest attorney or agent of the record in the patent file.

The paragraphs checked below are part of this communication:

___ 1. The party receiving the courtesy copy is the latest attorney or agent of record in the patent file.

___ 2. The person named to receive the correspondence in this proceeding has not been made the latest attorney or agent of record in the patent file because:

___ A. Requester's claim of ownership of the patent is not verified by the record.

___ B. The request papers are not signed with a real or apparent binding signature.

___ C. The mere naming of a correspondence addressee does not result in that person being appointed as the latest attorney or agent of record in the patent file.

___ 3. Addressee is the latest attorney or agent of record in the patent file.

___ 4. Other ____

/tplovelace/

Legal Instruments Examiner
Central Reexamination Unit 571-272-7705; FAX No. 571-273-9900

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CONFIRMATION NO. 8459

SERIAL NUMBER	FILING or 371(c) DATE	CLASS	GROUP ART UNIT	ATTORNEY DOCKET NO.
90/014,355	08/05/2019 RULE	251	3993	70965.01

APPLICANTS

INVENTORS
9749792, Residence Not Provided;
REIN TECH, INC (ASSIGNEE), CHEYENNE, WY;
PATENT OWNER, Residence Not Provided;

**** CONTINUING DATA ****************************
This application is a REX of 14/596,460 01/14/2015 PAT 9749792
which is a CIP of 12/539,150 08/11/2009 PAT 9061307
and is a CIP of 13/776,963 02/26/2013 PAT 9297150
and is a CIP of 14/561,271 12/05/2014 PAT 9494480
and claims benefit of 62/095,024 12/21/2014

**** FOREIGN APPLICATIONS ***************************

**** IF REQUIRED, FOREIGN FILING LICENSE GRANTED **** ** SMALL ENTITY **

Foreign Priority claimed ☐ Yes ☐ No 35 USC 119(a-d) conditions met ☐ Yes ☐ No Verified and Acknowledged ____ Examiner's Signature	☐ Met after Allowance ____ Initials	STATE OR COUNTRY	SHEETS DRAWINGS	TOTAL CLAIMS	INDEPENDENT CLAIMS
				34	2

ADDRESS

MICHAEL E. KLICPERA
PO BOX 573
LA JOLLA, CA 92038-0573
UNITED STATES

TITLE

Water Use Monitoring Apparatus

FILING FEE RECEIVED	FEES: Authority has been given in Paper	
6000	FEES: Authority has been given in Paper No.____________ to charge/credit DEPOSIT ACCOUNT No.____________ for following:	☐ All Fees ☐ 1.16 Fees (Filing) ☐ 1.17 Fees (Processing Ext. of time) ☐ 1.18 Fees (Issue) ☐ Other ____________ ☐ Credit

BIB (Rev. 05/07).

Patent Assignment Abstract of Title

Total Assignments: 1

Application #: 14596460 **Filing Dt:** 01/14/2015 **Patent #:** 9749792 **Issue Dt:** 08/29/2017
PCT #: NONE **Intl Reg #:** **Publication #:** US20160076909 **Pub Dt:** 03/17/2016
Inventor: Michael Edward Klicpera
Title: Water Use Monitoring Apparatus

Assignment: 1

Reel/Frame: 047325 / 0670 **Received:** 10/26/2018 **Recorded:** 10/26/2018 **Mailed:** 10/29/2018 **Pages:** 7
Conveyance: ASSIGNMENT OF ASSIGNORS INTEREST (SEE DOCUMENT FOR DETAILS).
Assignor: KLICPERA, MICHAEL **Exec Dt:** 08/20/2018
Assignee: REIN TECH, INC.
1712 PIONEER AVE, SUITE 5596
CHEYENNE, WYOMING 82001
Correspondent: PETER CORCORAN, CORCORAN IP LAW PLLC
2019 RICHMOND ROAD SUITE 380
TEXARKANA, TX 75503

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Web interface last modified: Jun 26, 2017 v.2.6

Doc code: IDS
Doc description: Information Disclosure Statement (IDS) Filed

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	14596460
	Filing Date	2015-01-14
	First Named Inventor	KLICPERA
	Art Unit	3753
	Examiner Name	JELLETT
	Attorney Docket Number	70965.01

U.S.PATENTS

Examiner Initial*	Cite No	Patent Number	Kind Code[1]	Issue Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
	1	8833390	B2	2014-09-16	BALL	Fig. 1-2, 11, 23, 29, and 31, Col. 3, lines 17-67,Col. 4, lines 1-31, Col. 8, lines 20-32, Col. 111 lines 7-28, Col. 12, lines 23-42, Col. 16, lines 17-67, Col. 17, lines 1-44
	2	9253754	B2	2016-02-02	SANDERFORD	Fig. 2 and 4, Col. 7, lines 2-67, Col. 9, lines 65-67, Col. 10, lines 1-43
	3	6539968	B1	2003-04-01	WHITE	Fig. 4 and 6, Col. 2, lines 43-51, Col. 5, lines 35-50, Claim 1
	4	5660198		1997-08-26	McCLARAN	Fig. 1, Col. lines 35-49, Col. 2, lines 15-25, 55-60, Col. 3, lines 10-40
	5	5636653		1997-06-10	TITUS	Fig. 2 and 16, Col. 2, lines 35-67, Col. 3, lines 1-3, Col. 4, lines 38-67, Col. 5, lines 1-67, Col. 6, lines 1-53, Col. 12, lines 42-60
	6	6105607	B2	2000-08-22	CAISE	Fig. 7, Col. 3, lines 33-67. Col. 5, lines 53-56
	7	6543479	B2	2003-04-08	COFFEY	Fig. 2, 4, and 5, Col. 2, lines 14-67, Col. 3, lines 38-56
	8	9019120	B2	2015-04-28	BRONIAK	Fig. 1, 2, and 3, Col. 3, lines 1-19, 52-67, Col. 4, lines 1-37, 56-63, Col. 5 lines 1-67

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)	Application Number	14596460
	Filing Date	2015-01-14
	First Named Inventor	KLICPERA
	Art Unit	3753
	Examiner Name	JELLETT
	Attorney Docket Number	70965.01

	9	4949976		1990-07-10	GASTOUNIOTIS	Fig. 1, Col. 3 lines 7-67, Col. 3 lines 40-65
	10	5298894		1994-03-29	CERNY	Fig. 2, 3, and 5, Col. 3 lines 6-52
	11	8539827	B2	2012-08-02	BENSON	Fig. 1, Col. 1 lines 45-48, Col.2 lines 47-57, 61-64, Col. 3 lines 3-4, 17-30, 64-67
	12	8644804	B2	2011-04-07	BLACKWELL	Col. 1 lines 7-10, 53-55, Col. 2 lines 31-33, 51-85. Col. 2 lines 63-76, Col. 3 lines 1-11
	13	8878690	B2	2010-12-23	OLSON	Fig. 2, 3, 4, and 5, Col. 1 lines 61-62, Col. 4 lines 3-8, 43-60, Col. 3, lines 22-25
	14	7012546	B1	2002-07-02	ZIGDON	Col. 5 lines 33-43, Col. 7 lines 12-19, 36-40, Col. 8, lines 35-38, Col. 10 lines 14-18
	15	8269651	B2	2006-11-02	ZIGDON	Col. 4 lines 46-58, Col. 5, lines 39-43, Col. 7 lines 2-6, 24-29, 36-40, Col. 8 lines 25-28,Col. 9 lines 66-67, Col. 10 lines 1-3, Col. 16 lines 47-49
	16	7626511	B2	2007-12-13	LAZAR	Col. 1 lines 104, Col. 3 lines 2-6, 21-26, 37-42, 54,60
	17	7605717	B2	2009-10-20	OLSON	Col. 2, lines 38-60, Col. lines 1-50, Col. 3 lines 1-14
	18	8217804	B2	2012-07-10	LAUGHLIN-PARKER	Col. 1, lines 14-60, Col. 3 lines 24-67
	19	8625722	B2	2014-01-07	ROUQUETTE	Col. 3 lines 5-50, Col. 6, lines 41-50, Col. 7 lines 17-47, Col. 8 lines 59-67, Col. 14, lines 32-43

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)	Application Number	14596460
	Filing Date	2015-01-14
	First Named Inventor	KLICPERA
	Art Unit	3753
	Examiner Name	JELLETT
	Attorney Docket Number	70965.01

	20	9253754	B2	2016-02-02	SANDERFORD	Fog. 1, 4, Col. 5, lines 60-65, Col. 8 lines 21-26, Col. 10 lines 22-35
	21	9417093	B2	2016-08-16	OLSON	Fig. 1, 3, 4, and 5, Col. 3 lines 44-67, Col. 4 lines 11-50
	22	9709421	B2	2017-07-18	BLACKWELL	Fig. 1, Col. 1 lines 46-67, Col. 3 lines 1-17, 25-67, Col. 4, lines 1-20
	23	8602384	B2	2013-12-10	WILLIAMSON	Fig. 1, Col. 2, lines 44-57
	24	5971011		1999-10-26	PRICE	Abstract, Col. 2, line 7-67, Col. 4, lines 7-28

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U.S.PATENT APPLICATION PUBLICATIONS

Examiner Initial*	Cite No	Publication Number	Kind Code[1]	Publication Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
	1	20040193329	A1	2004-09-30	RANSOM	Paragraphs 107, 110, 116, 118-123, 124-125, 127, 129, 133, 143, 144-145, 150, 162, 163-164, 166-167, 168, 173-174, 194.
	2	20080149180	A1	2008-08-26	PARRIS	Fig. 1, 7, 8,15 and 16, Paragraphs 96, 99, 109, 117, 121, 123, 141, 151, 156, 159-163, 171-173, 205, 212 220-221
	3	20080295895	A1	2008-12-04	VINCENT	Paragraphs 1, 10, 11, 13, 14
	4	20110035063	A1	2011-02-10	PALAYUR	Fig. 1-10, 14, 16-17, Paragraphs 8, 15, 16, 22-25, 36, 40, 69, 75, 80, 84, 91

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INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)	Application Number	14596460
	Filing Date	2015-01-14
	First Named Inventor	KLICPERA
	Art Unit	3753
	Examiner Name	JELLETT
	Attorney Docket Number	70965.01

FOREIGN PATENT DOCUMENTS

Examiner Initial*	Cite No	Foreign Document Number[3]	Country Code[2] i	Kind Code[4]	Publication Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear	T[5]
	1							☐

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NON-PATENT LITERATURE DOCUMENTS

Examiner Initials*	Cite No	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc), date, pages(s), volume-issue number(s), publisher, city and/or country where published.	T[5]
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EXAMINER SIGNATURE

Examiner Signature		Date Considered	

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through a citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

[1] See Kind Codes of USPTO Patent Documents at www.USPTO.GOV or MPEP 901.04. [2] Enter office that issued the document, by the two-letter code (WIPO Standard ST.3). [3] For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. [4] Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. [5] Applicant is to place a check mark here if English language translation is attached.

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	14596460
	Filing Date	2015-01-14
	First Named Inventor	KLICPERA
	Art Unit	3753
	Examiner Name	JELLETT
	Attorney Docket Number	70965.01

CERTIFICATION STATEMENT

Please see 37 CFR 1.97 and 1.98 to make the appropriate selection(s):

☒ That each item of information contained in the information disclosure statement was first cited in any communication from a foreign patent office in a counterpart foreign application not more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(1).

OR

☐ That no item of information contained in the information disclosure statement was cited in a communication from a foreign patent office in a counterpart foreign application, and, to the knowledge of the person signing the certification after making reasonable inquiry, no item of information contained in the information disclosure statement was known to any individual designated in 37 CFR 1.56(c) more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(2).

☐ See attached certification statement.

☐ The fee set forth in 37 CFR 1.17 (p) has been submitted herewith.

☐ A certification statement is not submitted herewith.

SIGNATURE

A signature of the applicant or representative is required in accordance with CFR 1.33, 10.18. Please see CFR 1.4(d) for the form of the signature.

Signature	/Michael Edward Klicpera	Date (YYYY-MM-DD)	2019-08-03
Name/Print	Michael Edward Klicpera	Registration Number	38044

Privacy Act Statement

The Privacy Act of 1974 (P.L. 93-579) requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

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6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).

7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.

8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspections or an issued patent.

9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

IN THE UNITED STATES PATENT & TRADEMARK OFFICE

IN RE REEXAMINATION OF U.S. PATENT NO. 9,749,792

INVENTOR: MICHAEL EDWARD KLICPERA

FILED: JANUARY 14, 2015

FOR: WATER USE MONITORING APPARATUS

PETITION UNDER 35 U.S.C. § 311 FOR EX PARTE REEXAMINATION OF

U.S. PATENT 9,749,792

MAIL STOP INTER PARTES REEXAMINATION
ATTN: CENTRAL REEXAMINATION UNIT
COMMISSIONER FOR PATENT
P.O. Box 1450
ALEXANDRIA, VA 22313-1450

Ex Parte Reexamination is petitioned in accordance with 35 U.S.C. § 302 and 37 C.F.R. §1.501 and 37 C.F.R. §1.510 for U.S. Patent No. 9,749,792 (hereinafter "the '792 Patent"). Substantial New Questions of Patentability (SNQs) are presented herein, based on additional prior art that has been brought to the Patent Holder's attention during litigation proceedings.

As required by 37 C.F.R. § 1.150(b)(1), a statement pointing out each substantial new question of patentability base on prior patents and printed publications.

As required by 37 C.F.R. § 1.150(b)(2), a full listing of the patents and printed publications presented to provide a substantial new question of patentability is included on a submitted with this Petition which is attached hereto, together with a full copy of each listed document in Exhibit A.

The submitted art was neither not previously provided to the USPTO or considered in the light presented to issuance of the '792 Patent.

Petitioner also petitions correction of the specification. Inventor conceived using encryption integrity, and authentication to provide secure wireless and wired communications for a water meter in a written document dated April 15, 2009 and started drafting water meter claims

for integrity, authentication, encryption and non-repudiation beginning on June 2, 2010. In September 2010, the Inventor confided with a companion that he desired to represent security technology in a detailed and professional manner when drafting a patent application for a water meter, and the companion told the Inventor he knew of an IT consultant that could be of assistance. The companion contacted the Inventor and conveyed that the IT consultant wanted the Inventor to provide an outline of information required and a payment of $1000. Upon receiving these items, the IT consultant would provide a detailed and professional document. The Inventor agree to fully compensate the IT professional, tendered payment and provide an outline document which included SSL, secure HTTP (HTTPs), Internet Protocols, XML technology, Public Key Encryption, and other technology. Within a week, the companion provided the Inventor with several detailed written pages for XML and XML signature technology, Public Key Encryption, Digital Signatures, Hash Functions, Secure Socket Layers, Secure HTTP, Internet Protocol Security and other technology. Inventor contends that an implied-in-fact contract exception, under employed-to-invent, was established between the IT consultant and the Inventor. There is unequivocal inference showing that the consultant was hired for the express purpose of producing the accomplished and professional wireless and security technology (see Florida v. Neal, 12 So. 2d, 590, 591, USPQ 175, 176 (Fla.)). The Inventor contends that IT Consultant was not an inventor and was provided an outline to produce a detailed, professional document.

It was later discovered that the IT professional copied and plagiarized sections from a Ransom published patent application number 2004/0193329. Inventor has included the Ransom published patent application in a currently submitted IDS, and have deleted the copied material, replacing with the Inventor's understanding and own wording.

TABLE OF CONTENTS

TABLE OF EXHIBITS

A. IDENTIFICATION OF CLAIMS FOR WHICH REEXAMINATION IS PETITIONED

B. STATEM POINTING OUT EACH SUBSTANTIAL NEW QUESTION OF PATENTABILITY

A. In accordance with 37 CFR 1.510, reexamination of claims 1, 2, 5, 6, 10, 12, 17, 24-27, 29, 31, and 34, in view of the following references.

(PA 1) "Energy Manager-Water Leak Detection" U.S. Patent 9,019,120 to Jay Andrew Broniak (hereinafter "Broniak") published on 4/25/2015, Prior Art under 35 U.S.C. §102(b) or 103(a)

(PA 2) "Water Management System" U.S. Published Application 2011/0035603 to Saju Anthony Palayur (hereinafter "Palayur") published on 2/10/2011, Prior Art under 35 U.S.C. §102(b) or 103(a)

(PA 3) "Valve Meter Assembly and Method" U.S. Patent 8,833,390 to Marty Scott Ball (hereinafter "Ball") published on 12/06/2012, Prior Art under 35 U.S.C. §102(b) or 103(a)

(PA 4) "Systems and Methods for Monitoring and Controlling Remote Devices" U.S. Patent 8,013,732 to Thomas D. Petite (hereinafter "Petite") published on 10/1/2009, Prior Art under 35 U.S.C. §103(a)

(PA 5) "Microprocessor Controlled Water Shut-Off Device" U.S. Patent 6,105,607 to Robert F. Caise (hereinafter "Caise"), published on 8/22/2000, Prior Art under 35 U.S.C. §103(a)

(PA 6) "Water Leakage and Fault Sensing System" U.S. Published Patent Application 2008/0295895 to Raymond Vincent et. al. (hereinafter "Vincent"), published on 12/04/2008, Prior Art under 35 U.S.C. §103(a)

(PA 7) "Water Meter with Integral Flow Restriction Valve" U.S. Patent 8,539,827 to Ronald Benson (hereinafter "Benson"), published on 8/2/2012, prior art under 35 U.S.C. §102(b) or 103(a)

(PA 8) "Method and System for Providing Web-Enabled Cellular Access to Meter Reading Data U.S. Patent 8,644,804 to Morrice Blackwell et. al. (hereinafter "Blackwell '804"), published on 4/7/2011, prior art under 35 U.S.C. §102(b) or 103(a)

(PA 9) "AMR Transmitter and Method Using Multiple Radio Messages" U.S. Patent 8,878,690 to John Olson et. al. (hereinafter Olson '690"), published on 12/23/2010, prior art under 35 U.S.C. §102(b) or 103(a)

(PA10) "Modular Wireless Fixed Network for Wide-Area Metering Data Collection and Meter Module Apparatus" U.S. Patent 7,012,546 to Shimon Zigdon (hereinafter "Zigdon '546"), published on 3/14/2006, prior art under 35 U.S.C. §102(b) or 103(a)

(PA 11) "Modular Wireless Fixed Network for Wide-Area Metering Data Collection and Meter Module Apparatus" U.S. Patent 8,269,651 to Shimon Zigdon (hereinafter "Zigdon '651"), published on 11/2/2006, prior art under 35 U.S.C. §102(b) or 103(a)

(PA 12) "AMR Transmitter and Method for Both Narrow Band and Frequency Hopping Transmissions" U.S. Patent 7,626,511 to Mark Lazar (hereinafter Lazar), published on 12/13/2007, prior art under 35 U.S.C. §102(b) or 103(a)

(PA 13) "Multi-Band Channel Capacity for Meter Network", U.S. Patent 9,253,754 to H. Sanderford (hereinafter Sanderford"), published on 6/28/2012 prior art under 35 U.S.C. §102(b) or 103(a), prior art under 35 U.S.C. §102(b) or 103(a)

(PA 14) "AMR Transmitter and Method Using Multiple Radio Messages" U.S. Patent 9,417,093 to John Olson et. al. (herein after "Olson '093"), published on 3/12/2015, prior art under 35 U.S.C. §102(b) or 103(a)

(PA 15) "Method and System for Providing Web-Enabled Cellular Access to Meter Reading Data" U.S. Patent 9,709,421 to Morrice Blackwell (hereinafter "Blackwell '421") published on 10/30/2014, prior art under 35 U.S.C. §102(b) or 103(a)

B. CLAIM CHARTS (CC)

(CC1) 35 U.S.C. § 102(b) Broniak anticipates claims 1, 2, 4, 6, 13, 24, 25, 26 and 31 of the '792 Patent

(CC2) 35 U.S.C. § 102(b) Palayur anticipates claims 1, 2, 4, 5, 6, 24, 25, 26 and 34 of the '792 Patent

(CC3) 35 U.S.C. § 103(a) Broniak in view of Palayur render claims 1-34 of the '792 Patent obvious

(CC4) 35 U.S.C. § 102(b) Ball anticipates claims 1, 2, 5, 6, 24, 25, 26 and 34 of the '792 Patent

(CC5) 35 U.S.C. § 103(a) Broniak in view of Palayur and further in view of Ball render claims 1, 2, 5, 6, 10, 13, 17, 24, 26, 25, 31 and 34 of the '792 Patent obvious

(CC6) 35 U.S.C. § 103(a) Broniak in view of Palayur and further in view of Ball, and in further view of Petite render claims 1, 2, 5, 6, 10, 13, 17, 24, 26, 25, 31 and 34 of the '792 Patent obvious

(CC7) 35 U.S.C. § 103(a) Broniak in view of Palayur and further in view of Ball and further in view of Caise render claims 1, 2, 5, 6, 10, 13, 17, 24, 26, 25, 31 and 34 of the '792 Patent obvious

(CC8) 35 U.S.C. § 103(a) Broniak in view of Palayur and further in view of Ball and further in view of Vincent render claims 1, 2, 5, 6, 10, 13, 17, 24, 26, 25, 31 and 34 of the '792 Patent obvious

(CC9) 35 U.S.C. § 102(b) Benson anticipated claims 1, 2, 4, 5, 6, 24, 25, 26 and 34 of the '792 Patent

(CC10) 35 U.S.C. § 102(b) Blackwell '804 anticipated claims 1, 2, 4, 5, 6, 24, 25, 26 and 34 of the '792 Patent

CC11) 35 U.S.C. § 102(b) Olson '690 anticipates claims 1, 2, 4, 5, 6, 24, 25, 26 and 34 of the '792 Patent

(CC12) 35 U.S.C. § 102(b) Zigdon '546 anticipates claims 1, 2, 4, 5, 6, 24, 25, 26 and 34 of the '792 Patent

(CC13) 35 U.S.C. § 102(b) Zigdon'651 anticipates claims 1, 2, 4, 5, 6, 24, 25, 26 and 34 of the '792 Patent

(CC14) 35 U.S.C. § 102(b) Lazar anticipates claims 1, 2, 4, 5, 6, 24, 25, 26 and 34 of the '792 Patent obvious

(CC15) 35 U.S.C. § 102(b) Sanderford anticipates claims 1, 2, 4, 5, 6, 24, 25, 26 and 34 of the '792 Patent

(CC16) 35 U.S.C. § 102(b) Olson '093 anticipates claims 1, 2, 4, 5, 6, 24, 25, 26 and 34 of the '792 Patent

(CC17) 35 U.S.C. § 102(b) Blackwell '421 anticipates claims 1, 2, 4, 5, 6, 24, 25, 26 and 34 of the '792 Patent

C. Amended Specification and Claims

D. Additional Information Disclosure Statement

E. Claim Charts

I. CONCURRENT PROCEEDINGS

U.S. Patent No. 9,749,792 is currently being asserted in *Rein Tech, Inc. v. Mueller Systems, LLC*, No. 1:18-cv-01683-MN (D. Del., filed Oct. 26, 2018).

II. REQUIREMENT FOR EX PARTE REEXAMINATION UNDER 37 C.F.R. § 1.510

The Real Party in Interest is Rein Tech, Inc.

A. 37 C.F.R. § 1.510(b)(1)

Under 35 USC § 302 and 37 CFR 1.510(b)(1), a statement pointing out each substantial new question of patentability based on the cited patents and printed publication, and a detailed explanation of the pertinence and manner of applying the patent and printed publications to claims 1, 2, 5, 6, 10, 13, 17, 24, 26, 25, 31 and 34 of the '792 Patent is presented below and accompany the claim charts. The relevant and cited patents disclosure water meters with leak detection capabilities, utilizing flow sensors, having one or more display means, and including one or more wireless communication means for transferring water parameter data and information to one or more remote monitoring apparatuses. Further shown in the claim charts is a comparison of claims 1, 2, 5, 6, 10, 13, 17, 24, 26, 25, 31 and 34 versus the disclosures in the cited prior art patents.

B. 37 C.F.R. § 1.510 (b)(2)

Pursuant to 37 C.F.R. § 1.195(b)(2) of every patent or printed publication relied upon to present an SNQ is submitted herein. All of these cited prior art publications constitute effective art references to the claims of the '792 Patents.

C. 37 C.F.R. § 1.510 (b)(3)

A full copy of this '792 Patent is submitted herein.

D. 37 C.F.R. § 1.150 (b)(4)

Since the inventor and owner of the '792 Patent is voluntarily submitting the '792 Patent for Reexamination, there is no requirement or need to server this Reexamination to any other entity.

E. 37 C.F.R. § 1.150 (b)(5)

Pursuant to 37 C.F.R. § 1.915(b)(5), Petitioner and Inventor Michael Edward Klicpera certifies that the ex partes reexamination estoppels provisions do not prohibit the filing of this *Ex Parte* reexamination.

An authorization registered with the Financial Manager Account of the Inventor to cover the $6000 Reexamination fee is attached. If this authorization is missing or defective, please charge the Fee to Deposit Account No. 502274.

111. GENERAL OVERVIEW OF THE ART REFERENCES IN THE PETITION

This petition presents the following art referenced patents and patent publications.

(PA 1) "Energy Manager-Water Leak Detection" to Jay Andrew Broniak	Published on 4/25/2015
(PA 2) "Valve Meter Assembly and Method" to Marty Scott Ball	Published on 12/06/2012
(PA 3) "Systems and Methods for Monitoring and Controlling Remote Devices" to Thomas D. Petite	Published on 10/1/2009
(PA 4) "Water Management System" to Saju Anthony Palayur	Published on 2/10/2011
(PA 5) "Microprocessor Controlled Water Shut-Off Device" to Robert F. Caise	Published on 8/22/2000
(PA 6) "Water Leakage and Fault Sensing System" to Raymond Vincent	Published on 12/4/2008
(PA 7) "Water Meter with Integral Flow Restriction Valve" U.S. Patent 8,539,827 to Ronald Benson	Published on 8/2/2012
(PA 8) "Method and System for Providing Web-Enabled Cellular Access to Meter Reading Data U.S. Patent 8,644,804 to Morrice Blackwell et. al.	Published on 4/7/2011,
(PA 9) "AMR Transmitter and Method Using Multiple Radio Messages" U.S. Patent 8,878,690 to John Olson et. al.	Published on 12/23/2010
(PA10) "Modular Wireless Fixed Network for Wide-Area Metering Data Collection and Meter Module Apparatus" U.S. Patent 7,012,546 to Shimon Zigdon	Published on 3/14/2006
(PA 11) "Modular Wireless Fixed Network for Wide-Area Metering Data Collection and Meter Module Apparatus" U.S. Patent 8,269,651 to Shimon Zigdon	Published on 11/2/2006
(PA 12) "AMR Transmitter and Method for Both Narrow Band and Frequency Hopping Transmissions" U.S. Patent 7,626,511 to Mark Lazar	Published on 12/13/2007

(PA 13) "Multi-Band Channel Capacity for Meter Network", U.S. Patent 9,253,754 to H. Sanderford	Published on 6/28/2012
(PA 14) "AMR Transmitter and Method Using Multiple Radio Messages" U.S. Patent 9,417,093 to John Olson et. al.	Published on 3/12/2015
(PA 15) "Method and System for Providing Web-Enabled Cellular Access to Meter Reading Data" U.S. Patent 9,709,421 to Morrice Blackwell	Published on 10/30/2014

The Broniak, Ball, Petite, Palayur, Caise, Benson, Vincent, Blackwell '804, Olson '690, Zigdon '546, Zigdon'651, Lazar, Sanderford , Olson '093, Blackell '421, were not of record in the file of the '792 Patent.

REEXAMINATION OF CLAIMS 1, 2, 24, 25, 26 AND 34 IS PETITIONED IN VIEW OF BRONIAK

Broniak raises a substantial new question of patentability for claims 1, 2, 24, 25, 26 and 34 as shown in the accompanying charts because it discloses a system for monitoring water leaks within a home having a network with various devices monitors these devices with a controller. Information is received from a water flow meter via a transceiver for tracking a total water flow amount through pipelines in the home. By comparing information collected to a predetermined threshold, a leak is determined as present or not within each pipeline. Upon the detection of a leak in the home, a homeowner is notified of the condition so that action is taken expeditiously. A shut off valve can be triggered remotely when a petition is received from the user, which closes the water pipeline to prevent water damage.

REEXAMINATION OF CLAIMS 1, 2, 5, 6, 24, 25, 26 AND 34 IS PETITIONED IN VIEW OF PALAYUR.

Palayur raises a substantial new question of patentability for claims 1, 2, 5, 6, 24, 25, 26 and 34 as shown in the accompanying charts because it discloses a water consumption monitoring and control system comprised of a base unit, comprising a display and a data entry device, a microprocessor, a communication link to water meters, pressure sensors, temperature sensors, flush toilet vibration sensors and shut-off valves. In addition, the base unit has access to the Internet and can access a server which holds a database of water conservation information. This database includes watering advisories from the local government, and weather information from the weather office. Palayur discloses that the communication links 23 can include communication from the sensors to the actuators. This communication can be implemented by means of a wire or wirelessly for example, by means of ISM band transceivers, Zigbee or WiFi. The communication also includes access to the Internet, either wirelessly, or by means of a wired ethernet.

REEXAMINATION OF CLAIMS 1, 2, 5, 6, 24, 25, 26 AND 34 IS PETITIONED IN VIEW OF BRONIAK IN VIEW OF PALAYUR.

Broniak raises a substantial new question of patentability for claims 1, 2, 24, 25, 26 and 34 as shown in the accompanying charts because it discloses a system for monitoring water leaks within a home having a network with various devices monitors these devices with a controller. Information is received from a water flow meter via a transceiver for tracking a total water flow amount through pipelines in the home. By comparing information collected to a predetermined threshold, a leak is determined as present or not within each pipeline. Upon the detection of a leak in the home, a homeowner is notified of the condition so that action is taken expeditiously. A shut off valve can be triggered remotely when a petition is received from the user, which closes the water pipeline to prevent water damage.

Palayur raises a substantial new question of patentability for claims 1, 2, 5, 6, 24, 25, 26 and 34 as shown in the accompanying charts because it discloses a water consumption monitoring and control system comprised of a base unit, comprising a display and a data entry device, a microprocessor, a communication link to water meters, pressure sensors, temperature sensors, flush toilet vibration sensors and shut-off valves. In addition, the base unit has access to the Internet and can access a server which holds a database of water conservation information. This database includes watering advisories from the local government, and weather information from the weather office. Palayur discloses that the communication links 23 can include communication from the sensors to the actuators. This communication can be implemented by means of a wire or wirelessly for example, by means of ISM band transceivers, Zigbee or WiFi. The communication also includes access to the Internet, either wirelessly, or by means of a wired ethernet.

REEXAMINATION OF CLAIMS 1, 2, 5, 6, 10, 13, 17, 24, 26, 25, 31 AND 34 IS PETITIONED IN VIEW OF BALL.

Ball raises a substantial new question of patentability for claims 1, 2, 5, 6, 10, 13, 17, 24, 26, 25, 31 and 34 as shown in the accompanying charts because it discloses a valve meter device including a housing defining at least one inlet opening and at least one outlet opening and a channel connecting the openings where the water meter configured to monitor control the flow of water through the valve meter device with a water control valve. Ball also discloses a wireless communication unit 2310 that include a wireless communication unit circuit 2925. The wireless communication unit circuit 2925 may be configured to log the status of the solenoid 270. For example, the communication unit circuit 2925 may log whether the solenoid 270 is in the open or closed position. Ball has a publication date of December 6, 2012 and a filing date of May 31, 2011.

REEXAMINATION OF CLAIMS 1, 2, 5, 6, 10, 13, 17, 24, 26, 25, 31 AND 34 IS PETITIONED IN VIEW OF BRONIAK IN VIEW OF PALAYUR IN FURTHER VIEW OF BALL.

Broniak raises a substantial new question of patentability for claims 1, 2, 24, 25, 26 and 34 as shown in the accompanying charts because it discloses a system for monitoring water leaks within a home having a network with various devices monitors these devices with a controller. Information is received from a water flow meter via a transceiver for tracking a total water flow amount through pipelines in the home. By comparing information collected to a predetermined threshold, a leak is determined as present or not within each pipeline. Upon the detection of a leak in the home, a homeowner is notified of the condition so that action is taken expeditiously.

A shut off valve can be triggered remotely when a petition is received from the user, which closes the water pipeline to prevent water damage.

Palayur raises a substantial new question of patentability for claims 1, 2, 5, 6, 24, 25, 26 and 34 as shown in the accompanying charts because it discloses a water consumption monitoring and control system comprised of a base unit, comprising a display and a data entry device, a microprocessor, a communication link to water meters, pressure sensors, temperature sensors, flush toilet vibration sensors and shut-off valves. In addition, the base unit has access to the Internet and can access a server which holds a database of water conservation information. This database includes watering advisories from the local government, and weather information from the weather office. Palayur discloses that the communication links 23 can include communication from the sensors to the actuators. This communication can be implemented by means of a wire or wirelessly for example, by means of ISM band transceivers, Zigbee or WiFi. The communication also includes access to the Internet, either wirelessly, or by means of a wired ethernet.

Ball raises a substantial new question of patentability for claims 1, 2, 5, 6, 10, 13, 17, 24, 26, 25, 31 and 34 as shown in the accompanying charts because it discloses a valve meter device including a housing defining at least one inlet opening and at least one outlet opening and a channel connecting the openings where the water meter configured to monitor control the flow of water through the valve meter device with a water control valve. Ball also discloses a wireless communication unit 2310 that include a wireless communication unit circuit 2925. The wireless communication unit circuit 2925 may be configured to log the status of the solenoid 270. For example, the communication unit circuit 2925 may log whether the solenoid 270 is in the open or closed position. Ball has a publication date of December 6, 2012 and a filing date of May 31, 2011.

<u>REEXAMINATION OF CLAIMS 1, 2, 5, 6, 10, 13, 17, 24, 26, 25, 31 AND 34 IS PETITIONED IN VIEW OF BRONIAK IN VIEW OF PALAYUR IN FURTHER VIEW OF BALL AND IN FURTHER VIEW OF PETITE.</u>

Broniak raises a substantial new question of patentability for claims 1, 2, 24, 25, 26 and 34 as shown in the accompanying charts because it discloses a system for monitoring water leaks within a home having a network with various devices monitors these devices with a controller. Information is received from a water flow meter via a transceiver for tracking a total water flow amount through pipelines in the home. By comparing information collected to a predetermined threshold, a leak is determined as present or not within each pipeline. Upon the detection of a leak in the home, a homeowner is notified of the condition so that action is taken expeditiously. A shut off valve can be triggered remotely when a petition is received from the user, which closes the water pipeline to prevent water damage.

Palayur raises a substantial new question of patentability for claims 1, 2, 5, 6, 24, 25, 26 and 34 as shown in the accompanying charts because it discloses a water consumption monitoring and control system comprised of a base unit, comprising a display and a data entry device, a microprocessor, a communication link to water meters, pressure sensors, temperature sensors, flush toilet vibration sensors and shut-off valves. In addition, the base unit has access to the Internet and can access a server which holds a database of water conservation information. This

database includes watering advisories from the local government, and weather information from the weather office. Palayur discloses that the communication links 23 can include communication from the sensors to the actuators. This communication can be implemented by means of a wire or wirelessly for example, by means of ISM band transceivers, Zigbee or WiFi. The communication also includes access to the Internet, either wirelessly, or by means of a wired ethernet.

Ball raises a substantial new question of patentability for claims 1, 2, 5, 6, 10, 13, 17, 24, 26, 25, 31 and 34 as shown in the accompanying charts because it discloses a valve meter device including a housing defining at least one inlet opening and at least one outlet opening and a channel connecting the openings where the water meter configured to monitor control the flow of water through the valve meter device with a water control valve. Ball also discloses a wireless communication unit 2310 that include a wireless communication unit circuit 2925. The wireless communication unit circuit 2925 may be configured to log the status of the solenoid 270. For example, the communication unit circuit 2925 may log whether the solenoid 270 is in the open or closed position. Ball has a publication date of December 6, 2012 and a filing date of May 31, 2011.

Petite raises a substantial new question of patentability for claims 1, 2, 5, 6, 10, 13, 17, 24, 26, 25, 31 and 34 as shown in the accompanying charts because it is directed to a system for monitoring a variety of environmental and/or other conditions within a defined remotely located region. The system is implemented by using a plurality of wireless transmitters, wherein each wireless transmitter is integrated into a sensor adapted to monitor a particular data input. The system also includes a plurality of transceivers that are dispersed throughout the region at defined locations. The system uses a local gateway to translate and transfer information from the transmitters to a dedicated computer on a network. Each stand-alone transceiver 211, 213, 215, and 221 and each of the integrated transceivers 212, 214, 216, 222, and 224 may be configured to receive an incoming RF transmission (transmitted by a remote transceiver) and to transmit an outgoing signal. This outgoing signal may be another low power RF transmission signal, a higher power RF transmission signal, or alternatively may be transmitted over a conductive wire, fiber optic cable, or other transmission media. The integrated transceivers 212, 214, 216, 222, and 224 can be replaced by RF transmitters for client specific applications that require data collection only. Local gateways 210 and 220 are configured and disposed to receive remote data transmissions from the various stand-alone transceivers 211, 213, 215, and 221 or integrated transceivers 212, 214, 216, 222, and 224 having an RF signal output level sufficient to adequately transmit a formatted data signal to the gateways. Local gateways 210 and 220 analyze the transmissions received, convert the transmissions into TCP/IP format and further communicate the remote data signal transmissions via WAN 230. Server 260 can be further networked with database server 270 to record client specific data. Petite states that integrated transceivers 212, 214, 216, 222, and 224 may be disposed within automobiles (see FIG. 7), a rainfall gauge (see FIG. 8), or a parking lot access gate (see FIG. 9) to monitor vehicle diagnostics, total rainfall and sprinkler supplied water, and access gate position, respectively. The controlled area 810 is configured with a rain gauge 813 integrated with sensor 811 wherein rainfall and applied water to the adjacent area is transmitted via functional codes by transmitter 812 along with a related transceiver identification code in a manner previously described to stand-alone transceiver 221. Server 260 collects and formats the rain gauge data for viewing or retrieval upon client demand in a manner

previously described. Additionally, server 260 may be configured to communicate data to operate spray head 817 by opening water supply valve 816 integrated with actuator 814 by sending a control signal to transceiver 815, per a client directed water application control schedule. Alternatively, a customer workstation 250 could periodically download and review the rain gauge data and could initiate an automatic control signal appropriate with the customer's watering requirements. In yet another embodiment, a customer technician could initiate a control signal upon review of the rain gauge information and making the determination that more water is required.

REEXAMINATION OF CLAIMS 1, 2, 5, 6, 10, 13, 17, 24, 26, 25, 31 AND 34 IS PETITIONED IN VIEW OF BRONIAK IN VIEW OF PALAYUR IN FURTHER VIEW OF BALL AND IN FURTHER VIEW OF CAISE

Broniak raises a substantial new question of patentability for claims 1, 2, 24, 25, 26 and 34 as shown in the accompanying charts because it discloses a system for monitoring water leaks within a home having a network with various devices monitors these devices with a controller. Information is received from a water flow meter via a transceiver for tracking a total water flow amount through pipelines in the home. By comparing information collected to a predetermined threshold, a leak is determined as present or not within each pipeline. Upon the detection of a leak in the home, a homeowner is notified of the condition so that action is taken expeditiously. A shut off valve can be triggered remotely when a petition is received from the user, which closes the water pipeline to prevent water damage.

Palayur raises a substantial new question of patentability for claims 1, 2, 5, 6, 24, 25, 26 and 34 as shown in the accompanying charts because it discloses a water consumption monitoring and control system comprised of a base unit, comprising a display and a data entry device, a microprocessor, a communication link to water meters, pressure sensors, temperature sensors, flush toilet vibration sensors and shut-off valves. In addition, the base unit has access to the Internet and can access a server which holds a database of water conservation information. This database includes watering advisories from the local government, and weather information from the weather office. Palayur discloses that the communication links 23 can include communication from the sensors to the actuators. This communication can be implemented by means of a wire or wirelessly for example, by means of ISM band transceivers, Zigbee or WiFi. The communication also includes access to the Internet, either wirelessly, or by means of a wired ethernet.

Ball raises a substantial new question of patentability for claims 1, 2, 5, 6, 10, 13, 17, 24, 26, 25, 31 and 34 as shown in the accompanying charts because it discloses a valve meter device including a housing defining at least one inlet opening and at least one outlet opening and a channel connecting the openings where the water meter configured to monitor control the flow of water through the valve meter device with a water control valve. Ball also discloses a wireless communication unit 2310 that include a wireless communication unit circuit 2925. The wireless communication unit circuit 2925 may be configured to log the status of the solenoid 270. For example, the communication unit circuit 2925 may log whether the solenoid 270 is in the open or closed position. Ball has a publication date of December 6, 2012 and a filing date of May 31, 2011.

Caise raises a substantial new question of patentability for claims 1, 2, 5, 6, 10, 13, 17, 24, 26, 25, 31 and 34 as shown in the accompanying charts because it discloses and claims a microprocessor-based control system to monitor flow in a potable water system and compare said flow with pre-set programs of time of day and duration of flow, if the pre-set parameters are exceeded the controller will turn off the flow of water. Caise discloses a flow sensor disclosed in Fig 3 and column 4, lines 10-39 is non-typical custom design that appears to be derived from sprinkler valves and not like current water meter flow sensors. It is not clear to one skilled in the art that this custom design can accurately monitor the actual water flow rate and it may be a binary flow sensor design monitoring flow or no flow condition.

REEXAMINATION OF CLAIMS 1, 2, 5, 6, 10, 13, 17, 24, 26, 25, 31 AND 34 IS PETITIONED IN VIEW OF BRONIAK IN VIEW OF PALAYUR IN FURTHER VIEW OF BALL AND IN FURTHER VIEW OF VINCENT

Broniak raises a substantial new question of patentability for claims 1, 2, 24, 25, 26 and 34 as shown in the accompanying charts because it discloses a system for monitoring water leaks within a home having a network with various devices monitors these devices with a controller. Information is received from a water flow meter via a transceiver for tracking a total water flow amount through pipelines in the home. By comparing information collected to a predetermined threshold, a leak is determined as present or not within each pipeline. Upon the detection of a leak in the home, a homeowner is notified of the condition so that action is taken expeditiously. A shut off valve can be triggered remotely when a petition is received from the user, which closes the water pipeline to prevent water damage.

Palayur raises a substantial new question of patentability for claims 1, 2, 5, 6, 24, 25, 26 and 34 as shown in the accompanying charts because it discloses a water consumption monitoring and control system comprised of a base unit, comprising a display and a data entry device, a microprocessor, a communication link to water meters, pressure sensors, temperature sensors, flush toilet vibration sensors and shut-off valves. In addition, the base unit has access to the Internet and can access a server which holds a database of water conservation information. This database includes watering advisories from the local government, and weather information from the weather office. Palayur discloses that the communication links 23 can include communication from the sensors to the actuators. This communication can be implemented by means of a wire or wirelessly for example, by means of ISM band transceivers, Zigbee or WiFi. The communication also includes access to the Internet, either wirelessly, or by means of a wired ethernet.

Ball raises a substantial new question of patentability for claims 1, 2, 5, 6, 10, 13, 17, 24, 26, 25, 31 and 34 as shown in the accompanying charts because it discloses a valve meter device including a housing defining at least one inlet opening and at least one outlet opening and a channel connecting the openings where the water meter configured to monitor control the flow of water through the valve meter device with a water control valve. Ball also discloses a wireless communication unit 2310 that include a wireless communication unit circuit 2925. The wireless communication unit circuit 2925 may be configured to log the status of the solenoid 270. For example, the communication unit circuit 2925 may log whether the solenoid 270 is in the open or closed position. Ball has a publication date of December 6, 2012 and a filing date of May 31, 2011.

REEXAMINATION OF CLAIMS 1, 2, 5, 6, 10, 13, 17, 24, 26, 25, 31 AND 34 IS PETITIONED IN VIEW OF BENSON

Benson raises a substantial new question of patentability for claims 1, 2, 5, 6, 10, 13, 17, 24, 26, 25, 31 and 34 as shown in the accompanying charts because it discloses a water meter and a flow control valve are housed in a common pressure vessel, in which the flow control valve restricts flow through a metering chamber to less than the normal flow, while still permitting a flow sufficient for basic human needs, rather than completely interrupting supply of the utility, and in which the flow control valve is controlled electrically through a control valve in an energy efficient manner so as to utilize power from a self-contained power source in another device at the customer site.

REEXAMINATION OF CLAIMS 1, 2, 5, 6, 10, 13, 17, 24, 26, 25, 31 AND 34 IS PETITIONED IN VIEW OF BLACKWELL '804

Blackwell '804 raises a substantial new question of patentability for claims 1, 2, 5, 6, 10, 13, 17, 24, 26, 25, 31 and 34 as shown in the accompanying charts because it discloses a method and a system for collection of meter readings from meter reading and transmitting devices and for viewing on a web-enabled wireless communication device comprises addressing at least one receiver through the Internet and obtaining a data file of meter data for a plurality of meter reading devices that have previously communicated with the receiver. The receiver can then re-transmit the meter data through a wide area network such as the Internet to a web site operated by an organization marketing AMR systems. The meter data is then accessed and displayed at a customer demonstration site using a handheld wireless smart phone which receives a web page that is reduced in size for transmission through the cellular network to the smart phone

REEXAMINATION OF CLAIMS 1, 2, 5, 6, 10, 13, 17, 24, 26, 25, 31 AND 34 IS PETITIONED IN VIEW OF OLSON '690

Olson '690 raises a substantial new question of patentability for claims 1, 2, 5, 6, 10, 13, 17, 24, 26, 25, 31 and 34 as shown in the accompanying charts because it discloses a method and several types of devices for converting meter reading signals into data messages including a first message having meter data representing consumption of a utility, and meter diagnostic status data, and a second message having meter reverse flow data and meter diagnostic data particular to an electronic flow meter, and receiving said first message and said second message and converting first message and said second message to radio frequency signals and transmitting said radio frequency signals to a receiver.

REEXAMINATION OF CLAIMS 1, 2, 5, 6, 10, 13, 17, 24, 26, 25, 31 AND 34 IS PETITIONED IN VIEW OF ZIGDON '546

Zigdon '546 raises a substantial new question of patentability for claims 1, 2, 5, 6, 10, 13, 17, 24, 26, 25, 31 and 34 as shown in the accompanying charts because it discloses a one way direct sequence spread spectrum (DSSS) communications wide-area network is the data collection channel (uplink) of an automatic meter reading (AMR) system, and a paging network, or other suitable communication channel is the optional forward (downlink) channel. The communications network may include one-way meter modules (transmitters) each

communicatively coupled to a corresponding electric, gas or water utility meter, and may include two-way meter modules (transceivers) each coupled to such a corresponding utility meter. The meter modules monitor, store, encode and periodically transmit metering data via radio signals (air messages) in an appropriate RF channel. Metering data air messages are collected by a network of receiver Base Stations (BS) and forwarded to a Data Operations Center (DOC), which acts as a metering data gateway. The reception range of each base station is typically over 5 miles in urban areas, allowing sparse infrastructure deployment for a wide variety of metering data collection applications.

REEXAMINATION OF CLAIMS 1, 2, 5, 6, 10, 13, 17, 24, 26, 25, 31 AND 34 IS PETITIONED IN VIEW OF ZIGDON '651

Zigdon '651 raises a substantial new question of patentability for claims 1, 2, 5, 6, 10, 13, 17, 24, 26, 25, 31 and 34 as shown in the accompanying charts because it discloses a one-way direct sequence spread spectrum (DSSS) communications wide-area network is the data collection channel (uplink) of an automatic meter reading (AMR) system, and a paging network, or other suitable communication channel is the optional forward (downlink) channel. The communications network may include one-way meter modules (transmitters) each communicatively coupled to a corresponding electric, gas or water utility meter, and may include two-way meter modules (transceivers) each coupled to such a corresponding utility meter. The meter modules monitor, store, encode and periodically transmit metering data via radio signals (air messages) in an appropriate RF channel. Metering data air messages are collected by a network of receiver Base Stations (BS) and forwarded to a Data Operations Center (DOC), which acts as a metering data gateway. The reception range of each base station is typically over 5 miles in urban areas, allowing sparse infrastructure deployment for a wide variety of metering data collection applications.

REEXAMINATION OF CLAIMS 1, 2, 5, 6, 10, 13, 17, 24, 26, 25, 31 AND 34 IS PETITIONED IN VIEW OF LAZAR

Lazar raises a substantial new question of patentability for claims 1, 2, 5, 6, 10, 13, 17, 24, 26, 25, 31 and 34 as shown in the accompanying charts because it discloses a method and circuitry for transmitting signals in both a narrow band, mobile-receiver type of AMR network and also for operation in the frequency-hopping, spread-spectrum, fixed-receiver type of AMR network. Unlike systems provided with multiple transmitters, the invention provides this in a single transmitter operating with common circuitry to transmit in two modes of transmission in a single operational sequence.

REEXAMINATION OF CLAIMS 1, 2, 5, 6, 10, 13, 17, 24, 26, 25, 31 AND 34 IS PETITIONED IN VIEW OF SANDERFORD

Sanderford raises a substantial new question of patentability for claims 1, 2, 5, 6, 10, 13, 17, 24, 26, 25, 31 and 34 as shown in the accompanying charts because it discloses a communication system that relays data messages from or to a plurality of remote endpoints via RF gateways to a data accumulation site over one of a series of communication channels. The communication system monitors the signal-to-noise ratio of communication from each individual endpoint, which can be utility meters and related control or monitoring points, to a gateway. Based upon a quality of service and/or the signal-to-noise ratio of the communication of the endpoints to the gateways, the system assigns a desired communication channel to the endpoint. Each of the desired communication channels have varying data transmission rate and required SNR and each channel is selected based upon the signal-to-noise ratio of the transmissions from the endpoint to the

gateways. If the signal-to-noise ratio changes for an endpoint, the system dynamically reassigns a different channel to the meter based upon the updated signal-to-noise ratio.

REEXAMINATION OF CLAIMS 1, 2, 5, 6, 10, 13, 17, 24, 26, 25, 31 AND 34 IS PETITIONED IN VIEW OF OLSON '093

Olson '093 raises a substantial new question of patentability for claims 1, 2, 5, 6, 10, 13, 17, 24, 26, 25, 31 and 34 as shown in the accompanying charts because it discloses a method and several types of devices for converting meter reading signals into data messages including a first message having meter data representing consumption of a utility, and meter diagnostic status data, and a second message having meter reverse flow data and meter diagnostic data particular to an electronic flow meter, and receiving, said first message and said second message and converting first message and said second message to radio frequency signals and transmitting said radio frequency signals to a receiver.

REEXAMINATION OF CLAIMS 1, 2, 5, 6, 10, 13, 17, 24, 26, 25, 31 AND 34 IS PETITIONED IN VIEW OF BLACKWELL '421

Blackwell'421 raises a substantial new question of patentability for claims 1, 2, 5, 6, 10, 13, 17, 24, 26, 25, 31 and 34 as shown in the accompanying charts because it discloses a method and a system for collection of meter readings from meter reading and transmitting devices and for viewing on a web-enabled wireless communication device comprises addressing at least one receiver through the Internet and obtaining a data file of meter data for a plurality of meter reading devices that have previously communicated with the receiver . The receiver can then re-transmit the meter data through a wide area network such as the Internet to a web site operated by an organization marketing AMR systems. The meter data is then accessed and displayed at a customer demonstration site using a handheld wireless smart phone which receives a web page that is reduced in size for transmission through the cellular network to the smart phone.

/Michael Klicpera/

Michael Klicpera

Electronic Patent Application Fee Transmittal	
Application Number:	
Filing Date:	
Title of Invention:	Water Use Monitoring Apparatus
First Named Inventor/Applicant Name:	Michael Edward Klicpera
Filer:	Michael E. Klicpera
Attorney Docket Number:	70965.01
Filed as Small Entity	

Filing Fees for **ex parte reexam**

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
EX PARTE REEXAMINATION (1.510(A)) NON-STREAMLINED	2812	1	6000	6000
Pages:				
Claims:				
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Extension-of-Time:				
Miscellaneous:				
		Total in USD ($)		**6000**

Electronic Acknowledgement Receipt

EFS ID:	36780265
Application Number:	90014355
International Application Number:	
Confirmation Number:	8459
Title of Invention:	Water Use Monitoring Apparatus
First Named Inventor/Applicant Name:	Michael Edward Klicpera
Customer Number:	22509
Filer:	Michael E. Klicpera
Filer Authorized By:	
Attorney Docket Number:	70965.01
Receipt Date:	05-AUG-2019
Filing Date:	
Time Stamp:	12:56:08
Application Type:	Reexam (Patent Owner)

Payment information:

Submitted with Payment	yes
Payment Type	CARD
Payment was successfully received in RAM	$6000
RAM confirmation Number	E201985C58238106
Deposit Account	
Authorized User	

The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows:

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Receipt of Original Ex Parte Reexam Request	Request_Ex_Parte_Reexamination_Transmittal_Form-792.pdf	250548 da5a48830c68b59df0e899d4a83ececd4ea029da	no	4
Warnings:					
Information:					
2	Receipt of Original Ex Parte Reexam Request	CC1-CC5_792.pdf	16233227 8d138d43db2b2dee1adddd154270a1381592acdb	no	45
Warnings:					
Information:					
3	Receipt of Original Ex Parte Reexam Request	CC6-CC10_792.pdf	18758456 81c546ed14440907d29f25d6c75902f33a99750b	no	54
Warnings:					
Information:					
4	Receipt of Original Ex Parte Reexam Request	CC11-CC17_792.pdf	16905898 17199db626d033ce15c91f8d0d4f51465a3b716c	no	56
Warnings:					
Information:					
5	Reexam - Info Disclosure Statement Filed by 3rd Party	Combined_PriorArtImage_Part1.pdf	19806545 d02dc8be20a4e62e3e95108e65dfcf43de8e9962	no	110
Warnings:					
Information:					
6	Reexam - Info Disclosure Statement Filed by 3rd Party	Combined_PriorArtImage_Part2.pdf	19891919 b2464d33fc7dd82e54c151480394c4022494d799	no	101
Warnings:					
Information:					

7	Reexam - Info Disclosure Statement Filed by 3rd Party	Combined_PriorArtImage_Part 3.pdf	6979685 211bef252f180ae2ba8679440fd70998ebb29822	no	55
Warnings:					
Information:					
8	Applicant Arguments/Remarks Made in an Amendment	Amended_Spec-and-Claims.pdf	11898840 4dbd9227de2fd72745fe835a9457850e1970cb39	no	39
Warnings:					
Information:					
9	Copy of patent for which reexamination is requested	9749792.pdf	13586529 e38e953280b575c8b7b5b7a5db089d230177ffeb	no	45
Warnings:					
Information:					
10	Information Disclosure Statement (IDS) Form (SB08)	updated_IDS460_image.pdf	1030104 9d04a25f77a5db123d75ed5e58270d9566d4aaf4	no	6
Warnings:					
Information:					
This is not an USPTO supplied IDS fillable form					
11	Receipt of Original Ex Parte Reexam Request	792_Reexamination_Letter.pdf	8242289 5eb7834fffac348a4ba145fc344307e6d39a4bc1	no	17
Warnings:					
Information:					
12	Fee Worksheet (SB06)	fee-info.pdf	30024 3e2de67827fc2b3f2bb2dc166e04ca9e2c235ede	no	2
Warnings:					
Information:					
		Total Files Size (in bytes):	133614064		

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111
If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.
National Stage of an International Application under 35 U.S.C. 371
If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.
New International Application Filed with the USPTO as a Receiving Office
If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

PTO/SB/57 (01-18)
Approved for use through 11/30/2021. OMB 0651-0064
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

(Also referred to as FORM PTO-1465)

REQUEST FOR *EX PARTE* REEXAMINATION TRANSMITTAL FORM

Address to:
Mail Stop *Ex Parte* Reexam
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Attorney Docket No.: 70965.01

Date: 8/5/2019

1. ☒ This is a request for *ex parte* reexamination pursuant to 37 CFR 1.510 of patent number 9,749,792 issued Aug. 29, 2017. The request is made by:
   ☒ patent owner. ☐ third party requester.

2. ☒ The name and address of the person requesting reexamination is:
   Rein Tech, Inc.
   P.O. Box 1164
   Alamo, CA 94507

3. Requester ☒ asserts small entity status (37 CFR 1.27) or ☐ certifies micro entity status (37 CFR 1.29). Only a patent owner requester can certify micro entity status. Form PTO/SB/15A or B must be attached to certify micro entity status.

4. This request is accompanied by payment of the reexamination fee as set forth in:
   ☒ 37 CFR 1.20(c)(2); **or**
   ☐ 37 CFR 1.20(c)(1). **In checking this box for payment of the fee set forth in 37 CFR 1.20(c)(1), requester asserts that this request has forty (40) or fewer pages and complies with all other requirements of 37 CFR 1.20(c)(1).**

   Payment of the reexamination fee is made by the method set forth below.
   a. ☐ A check in the amount of $__________ is enclosed to cover the reexamination fee;
   b. ☐ The Director is hereby authorized to charge the reexamination fee to Deposit Account No. __________;
   c. ☐ Payment by credit card. Form PTO-2038 is attached; **or**
   d. ☒ Payment made via EFS-Web.

   ☐ In addition, the Director is hereby authorized to charge any fee deficiencies to Deposit Account No. __________.

5. ☐ Any refund should be made by ☐ check or ☐ credit to Deposit Account No.__________. 37 CFR 1.26(c). If payment is made by credit card, refund must be to credit card account.

6. ☒ A copy of the patent to be reexamined having a double column format on one side of a separate paper is enclosed. 37 CFR 1.510(b)(4).

7. ☐ CD-ROM or CD-R in duplicate, Computer Program (Appendix) or large table
   ☐ Landscape Table on CD

[Page 1 of 3]

PTO/SB/57 (01-18)
Approved for use through 11/30/2021. OMB 0651-0064
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE

8. ☐ Nucleotide and/or Amino Acid Sequence Submission
If applicable, items a. – c. are required.
   a. ☐ Computer Readable Form (CRF)
   b. Specification Sequence Listing on:
      i. ☐ CD-ROM (2 copies) or CD-R (2 copies) **or**
      ii. ☐ paper
   c. ☐ Statements verifying identity of above copies.

9. ☐ A copy of any disclaimer, certificate of correction or reexamination certificate issued in the patent is included.

10. ■ Reexamination of claim(s) 1, 2, 5, 6, 10, 12, 17, 24-27, 29, 31 and 34 is requested.

11. ■ A copy of every patent or printed publication relied upon is submitted herewith including a listing thereof on Form PTO/SB/08, PTO-1449, or equivalent.

12. ☐ An English language translation of all necessary and pertinent non-English language patents and/or printed publications is attached.

13. ■ The attached detailed request includes at least the following items:
   a. A statement identifying each substantial new question of patentability based on prior patents and printed publications. 37 CFR 1.510(b)(1).
   b. An identification of every claim for which reexamination is requested, and a detailed explanation of the pertinency and manner of applying the cited art to every claim for which reexamination is requested. 37 CFR1.510(b)(2).

14. ■ A proposed amendment is included (only where the patent owner is the requester). 37 CFR 1.510(e).

15. ■ It is certified that the statutory estoppel provisions of 35 U.S.C. 315(e)(1) or 35 U.S.C. 325(e)(1) do not prohibit requester from filing this *ex parte* reexamination request. 37 CFR 1.510(b)(6).

16. Service
   a. ☐ It is certified that a copy of this request (if filed by other than the patent owner) has been served in its entirety on the patent owner as provided in 37 CFR 1.33(c).

   The name and address of the party served are:

   ____
   ____
   ____

   Date of Service: ______________________________

OR

   b. ☐ A duplicate copy is enclosed since service on patent owner was not possible. An explanation of the efforts made to serve patent owner **is attached**. See MPEP 2220.

PTO/SB/57 (01-18)
Approved for use through 11/30/2021. OMB 0651-0064
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE

17. Correspondence Address: Direct all communication about the reexamination to:

[x] The address associated with Customer Number: 22509

OR

[ ] Firm or Individual Name ______________________
(at the address identified below)

Address

City	State	Zip

Country

Telephone	Email

18. [ ] The patent is currently the subject of the following concurrent proceeding(s):

a. [ ] Copending reissue Application No. ______________________

b. [ ] Copending reexamination Control No. ______________________

c. [ ] Copending Interference No. ______________________

d. [x] Copending litigation styled:
U.S, Patent No. 9,749,792 is currently asserted in Rein Tech, Inc. v.
Mueller Systems, LLC No. 1:18-cv-01683-MN (D. Del. filed Oct. 26, 2018)

WARNING : Information on this form may become public. Credit card information should not be included on this form. Provide credit card information and authorization on PTO-2038.

/Michael Klicpera/	7/31/2019
Authorized Signature	Date
Michael Klicpera	38044
Typed/Printed Name	Registration No.

[x] For Patent Owner Requester [ ] For Third Party Requester

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IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re application of: Klicpera	)	
	)	
Serial Number: 14/596,460	)	
	)	Art Unit
Filed: 01/14/2015	)	3753
	)	
Examiner: Matthew Jellett	)	
	)	
For: Water Use Monitoring Apparatus	)	
	)	
Attorney Docket Number: 70965.01	)	

REEXAMINATION AMENDMENT

Honorable Commissioner of Patents and Trademarks
Mail Stop Reexamination
P.O. Box 1450
Alexandria, VA 22313-1450

Sir/Madam:

Please amend the above captioned patent application as follows:

Amendments to the Specification begin on page 2 of this paper.

Amendments to the Claims begin on page 25 of this paper.

AMENDMENTS TO THE SPECIFICATION

Please replace paragraph [57] with the following amended paragraph:

[57] ~~Several~~ There are many transfer protocols ~~different data formats~~ that may be used to communicate, and transfer water use and water quality data or information with the water meter and leak detection apparatus 10 (126 shown in Fig. 6). This list includes ~~exchange data, including but not limited to: binary,~~ XML technology, ~~XHTML and XHTML Basic, XHTML Basic as an Info-set in another form besides tagged text, Binary encoded equivalents of XML Info-sets including Wireless Binary XML ("WBXML"), ASN.1 encoded XML, SVG,~~ Direct Internet Message Encapsulation ("DIME"), ~~CSV, XML RPC,~~ Simple Object Access Protocol (SOAP) ~~SOAP (with signature at SOAP level and/or enclosed content level), SOAP (using WS-SECURITY with signature at SOAP level and/or enclosed content level), application specific content like spreadsheet data, an~~ a HTTP data message ~~response~~ to an unsolicited HTTP request, a Rest-API protocol or other supervisory control and data acquisition protocol that provides a control system architecture and/or protocol where a response can be incorporated into another protocol or format. ~~a response to an unsolicited message, HHF, PQDIF, MODBUS, ION.RTM., or other SCADA protocol where a response can be packaged up and embedded in another protocol or format. These formats are frequently sent as MIME or UUENCODE attachments and are considered part of the protocol stack.~~

Please replace paragraph [58] with the following amended paragraph:

[58] ~~The water/energy monitor and/or leak detections apparatus 10, 200 use monitoring activities~~ The water meter and leak detection apparatus 10 (126 shown in Fig. 6) will require ~~security due to economic impact or violation of municipal or governmental law and ordinances or fraudulent activities. SPOT is a technology that uses the FM band and is coupled with a new digital radio infrastructure.~~ The transfer of water use and water quality data or leak detection information using security measures due to violation of municipal or governmental laws and ordinances, and for obstructing fraudulent activities.

Please replace paragraph [59] with the following amended paragraph:

[59] ~~There are various security techniques, including encryption, authentication, integrity and non-repudiation that provide secure communications.~~ There are several important security techniques that taken as a whole, or in part, function to meet the objectives to, including authentication, integrity, encryption and non-repudiation that provide secure communications.

Please replace paragraph [60] with the following amended paragraph:

[60] ~~With Public Key Encryption, each user has a pair of keys, a public encryption key, and a private decryption key. A second user can send the first user a protected message by encrypting the message using the first user's public encryption key. The first user then decrypts the message using their private decryption key. The two keys are different, and it is not possible to calculate the private key from the public key. In most applications, the message is encrypted with a randomly generated session key, the random key is encrypted with the~~

~~public key and the encrypted message and encrypted key are sent to the recipient. The recipient uses their private key to decrypt the session key, and the newly decrypted session key to decrypt the message.~~ Two of the best-known uses of public key cryptography are the Public Key Encryption (PKE) and the Digital Signature protocols. PKE is a message or command signal that is encrypted with a recipient's public key. The message cannot be decrypted by any individual or machine that does not possess the matching private key. PKE is a security protocol that is used to maintain confidentiality. Similarly, Digital Signatures are messages or control signals that are signed with the sender's private key and that can be verified by any individual or machine that has access to the sender's public key. This verification proves that the sender had access to the private key, and therefore is likely to be the proper individual or machine to gain access to the message or command signal. Usually a one-way hash is utilized, which is defined as small portion or section of data that can identify and be associated a large volume of data or information that also provided authentication and integrity security measures. Hash functions are known to be resistant to reverse engineering (Secure Hash Algorithm). The Digital Signature protocol also ensures that the message or command signal has not been tampered with, as the original Digital Signature is mathematically bound to the message and verification will fail for practically any other message or command signal. Both PKE and Digital Signatures protocols can be used with the water meter and leak detection apparatus 10 (126 shown in Fig. 6 and 200 shown in Fig. 7 and 15). The strategy of PKE is that each user has a pair of keys; first, a public encryption key, and second, a private decryption key

Please delete paragraphs [61] and [62]:

Please replace paragraph [63] with the following amended paragraph:

[63] Various encryption algorithms ~~such as~~ include the original RSA algorithm, Advanced Encryption Standard (AES), Data Encryption Standard (DES) and Triple DES.

Please replace paragraph [64] with the following amended paragraph:

[64] ~~Secure Sockets Layer ("SSL")~~ Secure technologies include the Secure Sockets Layer ("SSL") which creates a secure connection between two communicating programs or applications. ~~For the purposes of the disclose embodiments, SSL and Transport Layer Security ("TLS") are equivalent. These protocols are employed by web browsers and web servers in conjunction with HTTP to perform cryptographically secure web transactions. A web resource retrievable with HTTP over TLS is usually represented by the protocol identifier "https" in the URI. TLS can and is used by a variety of Application protocols.~~ SSL is a standard security technology for establishing an encrypted link between a server and a client—typically a web server and a mail server or a mail client (e.g., Gmail). SSL uses encryption algorithms to scramble data while in transit, preventing hackers from reading it as it is sent over the internet or other connection. The SSL protocol are commonly utilized by web browsers and web servers in conjunction with HTTP protocol to perform cryptographically secure web transactions. Transport Layer Security (TLS) is an example of an updated, and more secure, version of SSL. A web resource retrievable with HTTP over SSL is usually represented by the protocol identifier "https" in the URL. Secure HTTP (S-HTTP) provides independently applicable security services for

transactions using confidentiality, authenticity and integrity technology.

Please delete paragraphs [65], [65] and [67];

Please replace paragraph [68] with the following amended paragraph:

[68] Another security technology is the Internet Protocol Security ("IPSec") ~~secures IP traffic across the Internet, and is particularly useful for implementing VPNs.~~ which protects internet protocol traffic across the Internet and is particularly useful for implementing VPNs that utilized tunnel and encryption techniques. IPSec originally utilized an IP authentication header. IP encapsulating security payload was an optional packed header that can provide superior confidentiality through encryption of the packet. Point-to-Point Tunneling Protocol ("PPTP") is another secure protocol that allows entities to extend their local network through private "tunnels" over the Internet. Layer Two Tunneling Protocol ("L2TP) is an extension of the PPTP protocol.

Please replace paragraph [69] with the following amended paragraph:

[69] A Media Access Control Address ("MAC Address") is a unique number ~~that is appended to a digital message and provides authentication and integrity for the message.~~ assigned to a network interface controller for communications with the data link layer of the Open Systems Interconnection Model (OSI Model). The MAC address is appended to a digital message and provides authentication and integrity for the message.

Please replace paragraph [70] with the following amended paragraph:

[70] ~~The XML Signature syntax associates a cryptographic signature value with Web resources using XML markup. XML signature also provides for the signing of XML data, whether that data is a fragment of the document which also holds the signature itself or a separate document, and whether the document is logically the same but physically different. This is important because the logically same XML fragment can be embodied differently. Different embodiments of logically equivalent XML fragments can be authenticated by converting to a common embodiment of the fragment before performing cryptographic functions. XML Encryption provides a process for encrypting/decrypting digital content, including XML documents and portions thereof, and an XML syntax used to represent the encrypted content and information that enables an intended recipient to decrypt it.~~ A further security protocol, the eXtensible Markup Language (XML) Signature associates a cryptographic signature value with Web resources using XML markup. XML signature also provides for the signing of XML data. Javascript object notation (JSON) has become more popular alternative to XML for various reasons, for example, JSON is less verbose than XML which uses more words than necessary and JSON is faster-parsing whereas XML software is generally slow and cumbersome.

Please replace paragraph [71] with the following amended paragraph:

[71] ~~Before the water/energy monitor and/or leak detection apparatuses 10, 200~~ The water meter and leak detection system 10 (126 shown in Fig. 6 and 200 shown in Fig. 7 and 15) should

communicate securely with remote displays/recorders 52, 54 or cell phone, smart phone, or similar apparatus 400 ~~should communicate securely with one another and therefore~~ and therefore they need to be provided with unique identities. The identity must not be easy to ~~assume~~ detect either intentionally or accidentally.

Please replace paragraph [72] with the following amended paragraph:

[72] ~~Identities are particularly~~ Residential and corporate location identity are particularly relevant in multi-site scenarios, where the water meter and leak detection apparatus 10 (126 shown in Fig. 6 and 200 shown in Fig. 7 and 15) are aggregated across a wide geographic area containing ~~municipal agencies~~ multiple sites, serviced by multiple utilities, each site operating on one or more municipal agencies. ~~Each water monitor and/or leak detection apparatus~~ each water meter and leak detection apparatus 10 (126 shown in Fig. 6 and 200 shown in Fig. 7 and 15) will need to identify itself when transmitting water use or water quality data or information, or queried by a civil, commercial, municipal or governmental operator or agency.

Please replace paragraph [73] with the following amended paragraph:

[73] ~~In one example, each water use/energy monitor and/or leak detection apparatus 10, 200~~ Each the water meter and leak system apparatus 10 (126 shown in Fig. 6 and 200 shown in Fig. 7 and 15) ~~will be identified and verified to see if its identification is already in the central storage.~~ will have its own identification means that will be recorded in a remote database. ~~This identity can be implemented using various values, including~~

~~MAC address Universal Unique Identifier ("UUID"), TCP/IP address, DNS name, email address, serial number, a unique string of characters issued by a municipal or governmental agency.~~ The identification can be the Media Access Control (MAC) address (OSI data layer), internet TCP/IP address (OSI transport and network layers), private or public property(ies) building address or users email address or incorporate a distinctive set of numbers or characters associated with a particular municipality or governmental agency.

Please replace paragraph [74] with the following amended paragraph:

[74] It is ~~important~~ essential that ~~within a given geographic area~~ no two ~~water monitor and/or leak detection apparatus 10, 200~~ water meter and leak detection systems 10 (126 shown in Fig. 6 and 200 shown in Fig. 7 and 15) will have the same identity within a specific geographical area. ~~It is therefore preferred that the entity, municipality or authority name become a portion of the identity. The fabrication process could include inserting a unique identity in the water monitor and/or leak detection apparatus 10, 200 at manufacturing or repair time.~~ It might be also be preferred that the entity, municipality or authority name become a portion of the unique identification code. During the fabrication process, the unique identification code could include adding a unique municipality or authority name code in the water meter and leak system apparatus 10 (126 shown in Fig. 6 and 200 shown in Fig. 7 and 15) or software downloaded upon installation or inserted during a repair or maintenance periods.

Please delete paragraph [75]:

Please replace paragraph [76] with the following amended paragraph:

[76] ~~PKI certificate based authentication schemes are utilized for machine-to-machine authentication. The water/energy use monitor and/or leak detection apparatus 10, 200 is issued one or more PKI certificates, associated identities and identity-related secrets, such as private keys, during manufacturing. Alternately, an identity and certificate are assigned by an authority unrelated to the device manufacturer and transferred to water monitor and/or leak detection apparatus 10, 200 in a manner that keeps all secrets private.~~ Public Key Infrastructure (PKI) can also be used in sensor/device to remote receiver situations where encryption and authentication techniques are required. However, many companies and governmental agencies replacing PKI with a two-step authentication procedure using recorded personal information including alternate email addresses and telephone numbers.

Please replace paragraph [77] with the following amended paragraph:

[77] ~~A user registry maintains a database of device identities~~ A unique identification code registry is maintained within a remote database that is associated with the installation and operation of the ~~water/energy use monitor and/or leak detection apparatus 10, 200.~~ water meter and leak detection system 10 (126 shown in Fig. 6 and 200 shown in Fig. 7 and 15). The unique identification code registry may be updated whenever a water meter and leak detection system 10 (126 shown in Fig. 6 and 200 shown in Fig. 7 and 15) is brought into or removed from service. The unique identification code registry may be ~~implemented as a distributed registry with a host name encoded within the~~

~~Metering Point corresponding to a registry for that particular host.~~ incorporated into the relevant remote database with a unique host name (municipality or governmental agency) or installation region encoded within unique identification code. This would result in several databases that are unique to a given municipality, governmental agency or geographic region. Alternatively, the unique identification registry can be implemented as a single large database. The registry can be implemented ~~distributed registry with a host name encoded within the Metering Point corresponding to a registry for that particular host.~~ as a relational database (e.g. MySQL, MariaSQL), non-relational database (e.g. Amazon DynamoDB), XML files, Comma Separated Value (CSV) Excel files, or Resource Description Files (RDF), or any mechanism that allows associated verification when combined with the appropriate software analysis. The unique identification registry enforces distinctiveness, thereby preventing two water meter and leak detection system 10 (126 shown in Fig. 6 and 200 shown in Fig. 7 and 15) from having the same unique identification code. ~~Alternatively, the registry can be implemented as a single large database. The registry can be implemented as a relational database, XML files, Comma Separated Value ("CSV") files, or Resource Description Files ("RDF"), or any mechanism that allows associated lookup when combined with the appropriate software. The registry enforces uniqueness of metering points, thereby preventing two devices from having the same identification address at the same instant.~~

Please replace paragraph [78] with the following amended paragraph:

[78] Encryption, authentication, integrity and non-repudiation may be important characteristics when the ~~water/energy use monitor and/or leak detection apparatus 10, 200~~ water meter and

leak detection system 10 (126 shown in Fig. 6 and 200 shown in Fig. 7 and 15) is ~~sharing data or information with the remote displays.~~ transferring water use or water quality data or information to a remote server/database via a public or private network that provide wireless subsequent access to registered computers and cell, smart and mobile phones 400. When ~~a water/energy use monitor and/or leak detection apparatus 10, 200~~ water meter and leak detection system 10 (126 shown in Fig. 6 and 200 shown in Fig. 7 and 15) receives or uploads data and information such as a control command signal to send or transmit data and information it is critical that the device can authenticate the sender and be sure of the integrity of the data and information. Encryption provides privacy by ~~preventing anyone but the intended recipient of a message from reading it.~~ converting the data or information into an "encrypted" code to prevent unauthorized access. Encryption can be provided point-to-point, or end-to-end, ~~depending on the nature of the channel and the data. Only a portion of the data may be encrypted. EM Components can encrypt messages using encryption schemes such as PGP, S/MIME, XML Encryption, or SSL. Signing data provides assurance that the data comes from the desired source, and that it has not been tampered with. Signing helps prevent so-called "man in the middle" attacks where someone with legitimate or illegitimate access to data intercepts the data and tampers with it or forges data. This can occur with all aspects of communication, including installing certificates, and exchanging frameworks and all types of EM data.~~ and transmit messages using encryption schemes such as Pretty Good Privacy (PGP), Secure/Multipurpose Internet Email (S/MIME), XML, or SSL encryption protocols. Non-repudiation prevents the sender from denying that they sent or received data/information or a message. Non-repudiation can be provided by signing, electronic witnessing and technologies that assert a document was read

before it was signed. One of the main advantages of the Block Chain technology is that non-repudiation is nearly immutable. Here, the water meter and leak detection system 10 (126 shown in Fig. 6 and 200 shown in Fig. 7 and 15) can include digital signature technology, data packets or messages using PGP, S/MIME, XML Signature or TLS/SSL to provide for non-repudiation of those messages, information or data.

Please replace paragraph [79] with the following amended paragraph:

[79] Non-repudiation prevents the sender from denying that they sent a message or that the receiver denying that they received a message. Non-repudiation can be provided by signing, electronic witnessing and technologies that assert a document was read before it was signed. ~~Similar techniques exist for ensuring non-repudiability of contracts. Here, the water use and water energy use monitoring apparatus 10, 126 include sign data, data packets or messages using PGP, S/MIME, XML Signature or TLS/SSL to provide for non-repudiation of those messages or data.~~

Please replace paragraph [236] with the following amended paragraph:

[236] To ensure that data and information transfer and communication is available at all times and that information or data has integrity that does not alter in any way when the cell phone, smart phone or similar apparatus 400 is not local but is in a remote long range location, and to endure that information or data has be correctly and promptly transferred, a remote service facility can be utilized with the present invention. In FIG. 10 is a block diagram of a method that provides additional integrity technology for the transfer of data. At a home or

business customer premises 442, a modem/server 438 connected to a cable, DSL, satellite or other service, e.g. T1 internet connection, that connects with the water use and water energy use monitoring display apparatus base station 200 vis wired 446 or wireless means 445. The ~~broadband~~ modem and router 438 connects to the internet ~~433~~ 434 via wired 440 or wireless 441 means and communicates with the governmental agency, insurance company, municipality agencies and/or third party station 470 via optional wired 466 or wireless 467 means or via an optional wired ~~466~~ 461 or wireless ~~467~~ 462 to a remote computer/server service center (cloud service provider) hosted by an insurance. municipality agencies and/or ~~third party~~ third-party monitoring[[,]] and data center[[)]] with the communications takes place via a communication network ~~434~~ 423, ~~436~~ 425 (e.g., cellular network, internet, etc.). The modem router/server 438 can communicate directly with a home owners mobile phone, smart phone, or similar mobile electronic apparatus 400 to the network utilizing communications that takes place via a communication network having wired 442, [[or]] wireless 423, or cellular network 436, via the internet 434 to cellular tower network communication 438 and via cellular tower network to mobile phone, smart phone or similar mobile electronic apparatus 400 using wireless communication 425. These Remote Operation Service Centers or cloud service provider 452 manage the system operations necessary to deliver the integrity of the system service described herein. The combination of the modem/router 438 and the Remote Operational Service Center or cloud service provider 452 enable a wide variety of support type devices [[430]] (e.g., PCs, mobile phones and PDAs, computers, televisions) to communicate with the water use and water energy use monitoring display apparatus base station 200 and allows users to remotely transfer water use, water energy use (water

quality data) or to control the residential or commercial water supply.

Please replace paragraph [237] with the following paragraph:

[237] Remote computer server center or cloud service provider 452 utilize cloud monitor tools, and more specifically [[,]] enable the cloud providers to track the performance, continuity and security of all the components that support service deliver, the hardware, the software and services in the data center and throughout the network infrastructure. Within the remote computer/service center 452 are service ~~management modules~~ provisioning and delivery management 454 which take an end-to-end approach to managing delivery and activation of services in an environment made increasing comply by ~~third parties~~ third-parties, multiple vendors and multiple technologies. The operational support system 456 utilize software applications that support customer~~-facing~~ activities such as billing, order management, customer management and cell center automation. The service provisioning and delivery management module 454 can communication by wired 455 or wireless 447 communication means between the business or operational support system 456. Other associated servers 458 may take other takes, such as database management, and utilize web services, XML, API technology 464. The service provisioning and delivery management module 454 can communication by wired 462 or wireless 439 communication means between the associated servers 458. The business or operational support system 456 can communication by wired 460 or wireless 469 communication means between the associated servers 458. These software programs and hardware use web services 464 such as XML, APIs and authentication (e.g. token) technology.

Please replace paragraph [239] with the following paragraph:

[239] In addition to HTTP or HTTPS communications the modem and router 438 and remote computer/server service center 452 can support the use of a cellular network 436 (both GPRS, GSM and CDMA options are available) as another means to provide the primary broadband connection 438 to the internet 434. Routers/servers such as those currently seen in homes or companies are enabled to communicate with the internet via a DSL line (over the switch telephone network (PTSN) or cable modem). One viable option is to build a cellular network circuitry into the broadband router or remote base station. As one example, a California manufacturer a microprocessor/microcontroller called the Electron that includes a SIM card and a unique cellular service. Alternately, a smart phone can be used as a "hotspot". When configured as such, the smart phone "hotspot" turns ~~instantly~~ into a broadband router to which the remotely communicates with the water use and water energy use monitoring display apparatus base station 200 (not shown in this Figure).

Please replace paragraph [240] with the following amended paragraph:

[240] FIG. 11 is a block diagram of components of the present invention~~, under an embodiment,~~ showing a more detailed description of the components. The ~~diverse~~ collection of apparatus/devices 480 range from computer ~~482~~, PC applications or programs in the system ~~484~~ or touch screen keypads, mobile phones, smart phones, or similar mobile electronic devices 400 ~~486~~, email ~~488~~, hub ~~490~~ or wireless (GPRS, GSM or CDMA) or internet connected televisions ~~492~~.

Please replace paragraph [241] with the following amended paragraph:

[241] The apparatus/devices 480 accessing a Web Portal application 494 through the internet 434, performs an end-user configuration and customization of the integrated service. In addition, device management is capable of performed ~~by this~~ as a portal application. A mobile device 486 (e.g., PDA, mobile phone, etc.) accessing the integrated system Mobile Portal 500. A mobile phone, smart phone or other mobile electronic device, 400 ~~484~~ ~~accessing~~ accesses the integrated Mobile Portal 500.

Please replace paragraph [242] with the following amended paragraph:

[242] There are numerous types of server components of the Remote Operation Data Service Center ~~452~~. Business Components which manage information about the controlling/monitoring devices~~, using Web 2.0, and XML APIs (see Figure 10)~~. Within the operational support systems/business support systems (OSS/BSS) ~~Components~~ modules are the Customer Help Desk 502 which provides information about remote devices and base station installment instructions and operation and technology questions. The Service Delivery and Management Application 504 enables operators to administer the service components. ~~(these components also access the Business Components via the XML APIs, and also via published SNMP MIBs)~~. Service provisioning 506 can be used to include a [[3rd]] third-party to monitor leak flow sensors located at a residence or company and provide alarms or send messages to the client when water leak problems are detected. If the residence or company hires a [3rd] third-party or has account with a [3rd] third-party, an insurance company

and/or municipality agencies, the Order, Management and Billing Component 508 will manage this service.

Please replace paragraph [244] with the following amended paragraph:

[244] The ~~low-level~~ service management ~~activities for the integrated system service. They~~ define all of the remote devices, for example, the cell phone, smart phone or similar apparatus 400, computer ~~browser~~, PC applications or programs, TV (with internet capability), associated with residential or corporate premise network, analyze how the devices interact, and trigger associated actions (such as sending signals to turn on or off the water system, or provide notifications to home or company owners). All changes in device states are monitored and logged for subsequent evaluation. The business components also manage all interactions with external systems as required, including sending alarms and other related self-monitoring data to the owners or the optional insurance, municipality agency or a third party monitoring station. The following Operational Support System (OSS) and Business Components (BSS) manage the main elements of the integrated security system service.~~, but the embodiment is not so limited:~~ A Registry Manager 526 defines and manages remote devices and networks. This component is also responsible for the creation, modification and termination of devices and networks. A Network Manager 524 defines and manages security and self-monitoring devices that are deployed on a network (site). This component handles the creation, modification, deletion and configuration of the devices, as well as the creation of automations, schedules and notification rules associated with those devices. An element management system 522 manages one or more of a specific ~~telecommunications~~ communication networks ~~elements~~. A Data Manager 532 manages

access to current and historical state data for an existing network and its devices. This component specifically does not provide any access to network management capabilities, such as adding new devices to a network, which are handled exclusively by the Network Manager 524. ~~To achieve optimal performance for all types of queries, data for current device states is stored separately from, but linked together, in the historical activity data (a.k.a. "logs") in the database.~~

Please replace paragraph [245] with the following amended paragraph:

[245] Additional operational support systems and business support systems direct manage communications with certain remote devices and systems. ~~For example,~~ The Hub Manager 530 directly manages all communications with the remotely located water use and water energy use monitoring display apparatus base station 200 and the remote devices 480 receiving information about device state changes, changing the configuration of devices, and downloading new versions or software updates to the remotely located water use and water energy use monitoring display apparatus base station 200 and/or remote devices 480 ~~hardware~~. A Notification Manager 528 is responsible for sending all notifications to clients via SMS (mobile phone messages), email (via a relay server like an SMTP email server)~~, etc~~. The Element Management System 522 is a ~~Business Component~~ business component that manages all activities associated with service installation[[,]] and scaling. ~~and monitoring, and filters and packages service operations data for use by the service management applications.~~

Please replace paragraph [246] with the following amended paragraph:

[246] The OSS/BSS store information about the water meters ~~devices~~ that they manage in the Control Service Database 536. The Control Service Database 536 stores information about users, networks, and devices ~~and logged activities~~. ~~This database interaction is performed via an appropriate interface~~. For security purposes, the various OSS/BSS manage all data storage and retrieval. The various Business Components provide web services-based APIs that application components use to access manage other modules and interfaces. ~~the various Business Components' capabilities~~. ~~Functions of application components include presenting integrated security system service data to end-users, performing administrative duties, and integrating with external systems and back-office applications.~~

Please replace paragraph [249] with the following amended paragraph:

[249] The OSS/BSS also have an XML-based interface 534 for quickly adding support for new devices to the integrated security system. ~~This interface 534 is a flexible, standards-based mechanism for defining the properties of new devices and how they can be managed. Although the~~ The format is flexible enough to allow the addition of any type of future device, pre-defined XML profiles are currently available for adding common types of devices such as new sensors 540 (e.g. water quality sensor).

Please replace paragraph [250] with the following amended paragraph:

[250] Once a user sets up a service, an Activation Application 494 delivers a first display to the user on either a display means on the water use and water energy use monitoring display apparatus base station 10, 126 and/or on a display means on the remote devices 480. ~~This pairing~~ Pairing technology or other application initiating secure means associates a new user with a purchased remote device 480 and the remotely water use and water energy use monitoring display apparatus base station 200. It primarily uses functionality published by the Provisioning API. Alternately, a Web Portal Application 496 can run on PC ~~browsers~~ and delivers the web-based interface to integrate water meter ~~the integrated system~~ devices. This application allows users to manage their water meter devices, observe water use, water energy use, and water quality trends, and program networks to ~~(e.g.~~ add devices and create automations[[)]] as well as to ~~view/change~~ modify device states (eg. turn on/off water valve). Because of the wide scope of capabilities of this Web Portal application, it uses ~~three different~~ Business Component APIs that include the Registry Manager API, Network Manager API, and Data Manager API. A Mobile Portal 500 is a small-footprint web-based interface that runs on mobile phones and PDAs. Potentially, the interaction with the Business Components is primarily via the Data Manager API. ~~Custom portals and targeted client applications can be provided leveraging the same Business Component APIs used by the above applications.~~ A Content Manager Application Component 498 delivers content to a variety of users. ~~It sends multimedia-rich user interface components to widget container clients (both PC and browser-based), as well as to advanced touch screen keypad clients.~~

Please replace paragraph [251] with the following amended paragraph:

[251] A number of application components ensure overall management of the OSS/BSS service. ~~These applications, referred to as Service Management Application Components 512, are configured to offer off-the-shelf solutions for production management of the integrated security system service including provisioning, overall service monitoring, customer support, and reporting, for example.~~ The Service Management Application Components 512 allows service administrators to perform activities associated with service installation, scaling and monitoring water use, water energy use and water quality data and [[/]]alerting for leak conditions. This application interacts ~~heavily~~ with the Element Management System 522 Business Component to execute its functionality~~, and also retrieves its monitoring data from that component via protocols such as SNMP MIBs~~. The CSR APP and Report Generator 510 is useful for provide reports in specific format for residential ~~home owners~~ home-owners and user, company owner and users, and/or the insurance company or a municipality agency. A Kitting Application 514 is used by employees performing service provisioning tasks. A Customer Help Desk 502 can be incorporated into the system to provide FAQs, installation and other service and water meter and communication hub maintenance calls. Service Delivery and Management 504 refers to the installing and management of the ~~remote controllable~~ base stations 200 at various residences and corporations. The Service Provisioning module 506 refers to the scheduling of maintenance of communication equipment and ~~remote controllable~~ base stations 200. The Order, Management and Billing module 508 relates to those services provided and management of services, such as monthly reports, surveillance programs, account receivables and well business costs, assets, liabilities and capital expenditures.

Please replace paragraph [253] with the following amended paragraph:

[253] Similar to the Open Systems Interconnection Model (OSI Model), the ~~The~~ control software includes a remote computer application layer 580 which is the main program that ~~orchestrates~~ coordinates the operations the device connection software 582, the modem/router connection 584 and the optional ~~base~~ LED/LCD display ~~panel connection 584~~. The Security Engine 588 provides ~~robust~~ protection against intentional and unintentional intrusion into the ~~integrated water use and water energy use monitoring and display apparatus remotely controllable~~ water meter base station 200 (10, 126) an optional communication hub both from inside the premises as well as from the WAN, LAN or Internet [[or]] potential intrusions ~~outside premises~~[[)]]. The Security Engine 588 comprises one or more ~~sub-modules or~~ components that perform functions including, but not limited to, ~~the following: Encryption~~ encryption including 128-bit SSL encryption to provide secure communications, [[.]] and ~~Bi-directional~~ authentication between the water use and water energy use ~~monitoring display apparatus~~ base station 200 (10, 126) and the remote device 480 is used to confirm that the data presentation is correct or software ~~instructs~~ instructions have been completed. Data sent from the modem/router server 444 to the remote device 480 (or vice versa) is digitally signed as an additional layer of security. Non-repudiation technology that prevents a sender from denying that a message, data or information was sent can also be incorporated. Digital signing provides both authentication and validation that the data has not been altered in transit. The modem/router 444 provides for 128-bit SSL encapsulation of signal data sent over the internet 434 for complete integrity. Wireless IEEE 802.11b/g/n/x with WEP, WPA-PSK (TKIPI, WPA2-PSK [AES], WPA-PSK ITKIP+WPA2-PSK IAES

or other security protocol variant to ensure that signals and communications always takes place using the strongest available protection. Attempts to activate gateway-enabled devices by intentional and unintentional intrusion are detected by the Security Engine. Pairing remote devices 480 have the information with the correct serial number or activation key (pairing) can be activated for use with the remotely located water use and water energy use ~~monitoring display apparatus~~ base station 200 (10, 126) or communication hub.

Amendments to the Claims

This listing of claims will replace all prior versions, and listing, of the claims in the application.

1. (currently amended) A water use monitoring and leak detection apparatus comprising:

a base station apparatus designed to be connected to a main water supply means;

said base station apparatus includes a joint means for connecting to a ~~cold/ambient~~ cold or ambient water supply, or a joint means for connecting to a ~~cold/ambient~~ cold or ambient water supply and a joint means for connecting to a hot water supply, said base station have a joint means for connecting to at least one outgoing water supply line~~(s)~~ for a home residence, company or building structure;

electrical circuitry including one or more CPUs, microprocessors or microcontrollers with a power source contained ~~with~~ in said base station apparatus;

said power source is ~~either~~ AC powered, DC powered, or powered with one or more batteries or one or more super capacitors, said power source is electrically connected to said electrical circuitry;

one or more flow sensors in communication with a water supply, said one or more flow sensors in electrical communication with said electrical circuitry;

a water control mechanism or a variable water flow mechanism in electrical communication with said electrical circuitry;

one or more wired or wireless electrical communication means, said wired or wireless electrical communication means having the capability to transfer water parameter, water energy ~~and/or~~ or water quality information or data to one or more remote apparatuses, said one or more wired or wireless electrical communication means utilizes protection technology to securely provide water use, water energy ~~and/or~~ or water quality information ~~and/or~~ or data in a confidential format;

said base station apparatus can include ~~includes~~ mesh-enabled circuitry that can communicate with other base stations for transferring water flow, water energy ~~and/or~~ or water quality data;

said base station apparatus ~~station(s) functioning as one or more access points that transfer~~ transfers to an internet connection said water flow water energy ~~and/or~~ or water quality data, using encryption and identification technology to an internet connection;

~~said one or more access points transfer said water flow, water energy and/or water quality data, using encryption and identification technology to the internet~~,

said water flow, water energy ~~and/or~~ or water quality data transferred over the internet connection to one or more remote computers or computer servers associated with one or more cloud service centers or to a private or corporate-owned network, and;

said one or more remote computers or computer servers associated

with a cloud service center ~~allow~~ allowing registered owners and users to access their registered water flow, water energy ~~and/or~~ or water quality data using a cell phone, smart phone, mobile phone, or a mobile electronic communication device.

2. (currently amended) A water use monitoring and leak detection apparatus comprising:

a base station in close proximity to a main water supply;

said base station ~~includes~~ having one or more [[a]] joint means for connecting to a ~~cold/ambient~~ cold or ambient water supply, ~~or a joint means for connecting to a cold/ambient water supply and a joint means for connecting to~~ a hot water supply, ~~said base station have a joint means for connecting to~~ and at least one outgoing water supply line ~~line(s)~~ for a home residence, company or building structure;

said base station further comprising a first power supply, ~~said first power supply is either~~ that is AC powered, DC powered, or powered with one or more batteries[[,]] and ~~said first power supply~~ electrically connected to a first circuitry having ~~which has~~ one or more CPUs, microprocessors or microcontrollers, said base station capable of including mesh technology to communicate with one or more other base stations;

one or more water flow sensors in communication with a water supply~~, said one or more water flow sensors~~ and in electrical connection with a first electrical circuity;

a water control mechanism or a variable water flow mechanism in electrical communication with said electrical circuitry;

said base station monitors and processes water parameter data including water flow, water energy, ~~and/or~~ or water quality data;

said base station includes software that controls and sequences the water parameter data and prepares said data for wired or wireless transfer;

a receiving station~~, said receiving station~~ having a second electrical circuitry including one or more second microprocessors~~, said receiving station~~ and remotely located from said base station;

said receiving station having a second power supply, ~~said second power supply~~ that is ~~either~~ AC powered ~~power~~, DC powered ~~power~~, or powered with one or more batteries or one or more super capacitors and~~, said second power supply~~ electrically connected to a second circuitry;

said first electrical circuitry of said base station is in ~~wire~~ wired or wireless communication with said second electrical circuity of said receiving station;

said receiving station designed to establish a Wi-Fi, Bluetooth or ZigBee electrical communication with a wireless router or server ~~router/server~~, ~~and/or~~ or cellular communication with [[a]] cell tower technology~~, and any combinations thereof~~;

said receiving station is capable of including ~~includes~~ mesh-enabled circuitry that can communicate with other receiving stations for transferring water flow, water energy ~~and/or~~ or water quality data ~~to one or more access points~~ using encryption and identification technology;

said receiving station or a custom receiving ~~transfer~~ apparatus ~~functioning as one or more access points for~~ transferring said water flow, water energy ~~and/or~~ or water quality data over an internet connection to one or more remote computers, [[or]] computer servers associated with one or more cloud services or to a private or corporate-owned network; and

said one or more remote computers, computer servers associated with one or more cloud service centers or to a private or corporate-owned network ~~allow~~ allowing registered owners and users to access their registered water flow, water energy ~~and/or~~ or water quality data using a cell phone, smart phone, mobile phone or a mobile electronic communication device.

3. (currently amended) The water use monitoring and leak detection apparatus of claim 1, wherein ~~said cell phone, smart phones, mobile phones,~~ other mobile electronic communication device including ~~such as~~ at least one of a PDA, ~~PDAs,~~ computer tablet ~~tablets (refers to all current and variants, revisions and generations of the APPLE®, SAMSUNG®, HP®, ACER®, MICROSOFT®, NOOK®, GOOGLE®, SONY®, KINDLE® and other tablets manufactured by these and other manufactures), APPLE TOUCH®, a~~ smart or internet capable television, wireless timepiece or wireless watch and other electronic apparatuses with Wi-Fi and wireless capability~~, and remote computers and controllers having internet, wireless cell format technology connectivity utilizing cellular, Wi-Fi, ZigBee and/or Bluetooth, and any combinations thereof, to communication with the remote cellular phones (with cellular equipment, public switched telephone network lines, satellite, microwave, tower and mesh technology~~.

4. (currently amended) The water use monitoring and leak

detection apparatus of claim 2, wherein ~~said cell phone, smart phones, mobile phones,~~ other mobile electronic communication device including ~~such as~~ at least one of a PDA, ~~PDAs,~~ computer tablet ~~tablets (refers to all current and variants, revisions and generations of the APPLE®, SAMSUNG®, HP®, ACER®, MICROSOFT®, NOOK®, GOOGLE®, SONY®, KINDLE® and other tablets manufactured by these and other manufactures), APPLE TOUCH®, a~~ smart or internet capable television, wireless timepiece or wireless watch and other electronic apparatuses with Wi-Fi and wireless capability~~, and remote computers and controllers having internet, wireless cell format technology connectivity utilizing cellular, Wi-Fi, ZigBee and/or Bluetooth, and any combinations thereof, to communication with the remote cellular phones (with cellular equipment, public switched telephone network lines, satellite, microwave, tower and mesh technology~~.

5. (currently amended) The water use monitoring and leak detection apparatus of claim 1, ~~further comprising~~ wherein said ~~base station including an electronic water control valve wherein said base station~~ water control mechanism or a variable water flow mechanism is programmed to automatically turns off the main water supply when a leak is detected or ~~alternately~~ said base station ~~can send~~ sending an alert signal when a leak is detected to [[a]] said cell phone, smart phone, mobile phone, or other mobile electronic communication device, ~~wherein~~ whereby a user is provided an election to send a command to the base station to control the electronic water control valve to turn off or leave on the main water supply.

6. (currently amended) The water use monitoring and leak detection apparatus of claim 1, wherein said one or more water flow sensors includes independent flow sensors for the main water supply, an irrigation water supply, one or more showers,

one or more hot water heaters, one or more washing machines, one or more dishwashers, one or more kitchen faucets, one or more bathroom faucets, one or more toilets, one or more refrigerator water dispenser or ice maker, a Jacuzzi water supply, a pool water supply, ~~and/or~~ or a fountain water supply~~, any other water use device, or any combinations thereof~~ the communicates using wired or wireless technology with said base station apparatus.

7. (currently amended) The water use monitoring and leak detection apparatus of claim 1, further comprising a water use calibration mode for learning the patterns and signatures of water use devices within a home, corporation, building or structure.

8. (currently amended) The water use monitoring and leak detection apparatus of claim 1, further comprising an automatic learning mode ~~whereby~~ having learning software that privately tracks an owner's water flow rate, water duration and total volume use for a period~~, assigning~~ and assigns water patterns and water signatures to each specific water use device.

9. (currently amended) The water use monitoring and leak detection apparatus of claim 2, further comprising a water use calibration mode for learning the patterns and signature of water use devices within a home, corporation, building or structure.

10. (currently amended) The water use monitoring and leak detection apparatus of claim 2, further comprising an automatic learning mode ~~whereby~~ having learning software that privately tracks an owner's water flow rate, water duration and total volume use for a period~~, assigning~~ and assigns water patterns and water signatures to each specific water use device.

11. (previously presented) The water use monitoring and leak detection apparatus of claim 1, wherein said cell phone, smart phones, mobile phone, or other mobile electronic communication device utilizes geo-fencing technology to provide an owner or user information that they have traveled beyond the defined geo-fence territory and provides the owner or user the option to turn on and off the main water supply.

12. (currently amended) The water use monitoring and leak detection apparatus of claim 1, ~~further comprising a~~ wherein said water control mechanism ~~means~~ or [[a]] said variable water flow mechanism is ~~means~~, ~~said water control means or variable water flow means~~ controlled by programming instructions from said one or more CPUs, microprocessors or microcontroller ~~microprocessor or microcontroller~~ for turning on and off said water control ~~means~~ mechanism or setting a variable water flow ~~means~~ mechanism, said water control ~~means~~ mechanism or variable water flow ~~means~~ mechanism ~~can be~~ is capable of being activated by an owner's or user's cell phone, smart phones, ~~or~~ mobile phone, ~~or other~~ mobile electronic communication device, ~~or by~~ a remote apparatus or remote computer, computer servers associated with one or more cloud service centers or ~~alternately activated~~ by said one or more wireless or wired communication means controlled by a municipality or governmental agency.

13. (previously presented) The water use monitoring and leak detection apparatus of claim 2, wherein said cell phone, smart phones, mobile phone, or other mobile electronic communication device utilizes geo-fencing technology to provide an owner or user information that they have traveled beyond the defined geo-fence territory and provides the owner or user the option to

turn on and off the main water supply.

14. (currently amended) The water use monitoring and leak detection apparatus of claim 1, ~~further comprising a~~ wherein said water control mechanism ~~means~~ or [[a]] said variable water flow mechanism is ~~means~~, ~~said water control means or variable water flow means~~ controlled by programming instructions from said one or more CPUs, microprocessors or microcontroller ~~microprocessor or microcontroller~~ for turning on and off said water control ~~means~~ mechanism or setting a variable water flow ~~means~~ mechanism, said water control ~~means~~ mechanism or variable water flow ~~means~~ mechanism ~~can be~~ is capable of being activated by an owner's or user's cell phone, smart phones, ~~or~~ mobile phone, ~~or other~~ mobile electronic communication device, ~~or by~~ a remote apparatus or remote computer, computer servers associated with one or more cloud service centers or ~~alternately activated~~ by said one or more wireless or wired communication means controlled by a municipality or governmental agency.

15. (currently amended) The water use monitoring and leak detection apparatus of claim 1, wherein the transfer of water use, water energy, ~~and/or~~ or water quality can "piggy back" on smart electric ~~and/or~~ or gas data transfer protocols whereby a third wireless means has the capability to "piggy back" or be designed to be incorporated into ~~and/or~~ or cooperation with electric and gas smart meters ~~communication/transmission~~ communication or transmission mesh technology.

16. (previously presented) The water use ~~and~~ monitoring and leak detection apparatus of claim 3, wherein said cell phone, smart phones, mobile phone, or other mobile electronic communication device with wireless communication can automatically convert back and forth from radio frequency format, ZigBee or Bluetooth

format to a cellular format technology to accommodate range requirements.

17. (previously presented) The water use monitoring and leak detection apparatus of claim 1, wherein the base station can be incorporated into or serve as the pressure regulator or primary water meter at a residential home or commercial facility.

18. (currently amended) The water use monitoring and leak detection apparatus of claim 1, wherein the transfer of water use, water energy, ~~and/or~~ or water quality can "piggy back" on smart electric ~~and/or~~ or gas data transfer protocols whereby a third wireless means has the capability to "piggy back" or be designed to be incorporated into ~~and/or~~ or cooperation with electric and gas smart meters ~~communication/transmission~~ communication or transmission mesh technology.

19. (previously presented) The water use monitoring and leak detection apparatus of claim 2, wherein the base station can be incorporated into or serve as the pressure regulator or primary water meter at a residential home or commercial facility.

20. (currently amended) The water use monitoring and leak detection apparatus of claim 1, further comprising a water flow generation apparatus that can be utilized with rechargeable batteries or super capacitors that are~~, said rechargeable batteries being~~ supplemented with ~~whereby~~ electrical energy generated by a turbine or other water flow type electrical generation means in hydraulic connection with said water supply source for powering the base unit.

21. (currently amended) The water use ~~and~~ monitoring and leak detection apparatus of claim 1, wherein a single flow rate

sensor monitors and detects the source use for one or more main water supplies ~~supply~~, one or more irrigation systems, one or more showers, one or more hot water heaters, one or more washing machines, one or more dishwashers, one or more kitchen faucets, one or more bathroom faucets, one or more toilets, one or more refrigerators with water dispensers and ice making supply lines, one or more Jacuzzis ~~Jacuzzi(s)~~, one or more pool water supplies, ~~and/or~~ or one or more fountain water supplies~~, any other water use device, or any combinations thereof~~, the base station software recording a unique water pattern or water signature for each water use device.

22. (currently amended) The water use monitoring and leak detection apparatus of claim 1, further comprising ~~wherein said~~ monitoring and water source detection that is capable of being ~~can be~~ displayed in a line, graphical or other format one or more wireless or wired remote apparatuses comprises a typical cell phone, smart phones, mobile phone, or other mobile electronic communication device.

23. (currently amended) The water use monitoring and leak detection apparatus of claim 2, ~~further comprising~~ wherein said ~~base station including an electronic water control valve wherein said base station~~ water control mechanism or a variable water flow mechanism is programmed to automatically turns off the main water supply when a leak is detected or ~~alternately~~ said base station ~~can send~~ sending an alert signal when a leak is detected to [[a]] said cell phone, smart phone, mobile phone, or other mobile electronic communication device, ~~wherein~~ whereby a user is provided an election to send a command to the base station to control the electronic water control valve to turn off or leave on the main water supply.

24. (currently amended) The water use ~~and~~ monitoring and leak detection apparatus of claim 2, wherein a single flow rate sensor monitors and detects the source use for one or more main water supplies ~~supply~~, one or more irrigation systems, one or more showers, one or more hot water heaters, one or more washing machines, one or more dishwashers, one or more kitchen faucets, one or more bathroom faucets, one or more toilets, one or more refrigerators with water dispensers and ice making supply lines, one or more Jacuzzis ~~Jacuzzi(s)~~, one or more pool water supplies, ~~and/or~~ or one or more fountain water supplies~~, any other water use device, or any combinations thereof~~, the base station software recording a unique water pattern or water signature for each water use device.

25. (currently amended) The water use monitoring and leak detection apparatus of claim 2, further comprising a water flow generation apparatus that can be utilized with rechargeable batteries or super capacitors that are~~, said rechargeable batteries being~~ supplemented with ~~whereby~~ electrical energy generated by a turbine or other water flow type electrical generation means in hydraulic connection with said water supply source for powering the base unit.

26. (currently amended) The water use ~~and~~ monitoring and leak detection apparatus of claim 2, wherein a single flow rate sensor monitors and detects the source use for one or more main water supplies ~~supply~~, one or more irrigation systems, one or more showers, one or more hot water heaters, one or more washing machines, one or more dishwashers, one or more kitchen faucets, one or more bathroom faucets, one or more toilets, one or more refrigerators with water dispensers and ice making supply lines, one or more Jacuzzis ~~Jacuzzi(s)~~, one or more pool water supplies, ~~and/or~~ or one or more fountain water supplies~~, any~~

~~other water use device, or any combinations thereof~~, the base station software recording a unique water pattern or water signature for each water use device.

27. (currently amended) The water use monitoring and leak detection apparatus of claim 1, further comprising ~~wherein said~~ monitoring and water source detection that is capable of being ~~can be~~ displayed in a line, graphical or other format one or more wireless or wired remote apparatuses compromising ~~comprises~~ a typical cell phone, smart phones, mobile phone, or other mobile electronic communication device.

28. (currently amended) The water use monitoring apparatus of claim 1, further compromising one or more pressure sensors~~, said one or more pressure sensors~~ in electrical connection with said first electrical circuity.

29. (currently amended) The water use monitoring and leak detection apparatus of claim 1, further compromising one or more temperature sensors~~, said one or more temperature sensors~~ in electrical connection with said first electrical circuity.

30. (currently amended) The water use monitoring and leak detection apparatus of claim 1, further compromising one or more acoustic/sound monitoring sensors~~, said one or more acoustic/sound monitoring sensors~~ in electrical connection with said first electrical circuity.

31. (currently amended) The water use monitoring and leak detection apparatus of claim 2, further comprising one or more pressure sensors~~, said one or more pressure sensors~~ in electrical connection with said first electrical circuity.

32. (currently amended) The water use monitoring and leak detection apparatus of claim 2, further comprising one or more temperature sensors~~, said one or more temperature sensors~~ in electrical connection with said first electrical circuity.

33. (currently amended) The water use monitoring and leak detection apparatus of claim 2, further comprising one or more acoustic/sound monitoring sensors~~, said one or more acoustic/sound monitoring sensors~~ in electrical connection with said first electrical circuity.

34. (previously presented) The water use monitoring and leak detection apparatus of claim 4, wherein said cell phone, smart phones, mobile phone or other mobile electronic communication device with wireless communication can automatically convert back and forth from radio frequency format, ZigBee or Bluetooth format to a cellular format technology to accommodate range requirements.

35. (new) The water use monitoring and leak detection apparatus of claim 1, further comprising said one or more remote computers, computer servers associated with one or more cloud service centers or to a private or corporate-owned network ~~allow~~ allowing registered owners and users to access their registered water flow, water energy or water quality data on a remote computer use a web base web portal program.

36. (new) The water use monitoring and leak detection apparatus of claim 2, further comprising said one or more remote computers, computer servers associated with one or more cloud service centers or to a private or corporate-owned network ~~allow~~

allowing registered owners and users to access their registered water flow, water energy or water quality data on a remote computer use a web base web portal program.

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Klicpera

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(45) **Date of Patent:** ***Aug. 29, 2017**

(54) **WATER USE MONITORING APPARATUS**

(71) Applicant: **Michael Edward Klicpera**, La Jolla, CA (US)

(72) Inventor: **Michael Edward Klicpera**, La Jolla, CA (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

This patent is subject to a terminal disclaimer.

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(51) **Int. Cl.**

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H04W 4/02	(2009.01)
G06Q 50/06	(2012.01)
F16K 31/05	(2006.01)
F16K 31/02	(2006.01)

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CPC ***H04W 4/021*** (2013.01); ***E03B 7/071*** (2013.01); ***F16K 31/02*** (2013.01); ***F16K 31/05*** (2013.01); ***G01F 15/066*** (2013.01); ***G01F 15/0755*** (2013.01); ***G06Q 50/06*** (2013.01); *G01F 1/10* (2013.01); *G01F 1/3209* (2013.01); *G01F 1/58* (2013.01); *G01F 1/66* (2013.01); *G01F 1/68* (2013.01); *G01F 1/84* (2013.01);
(Continued)

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CPC Y10T 137/86397; Y10T 137/86389; F16K 31/02; F16K 31/05; E03B 7/071
See application file for complete search history.

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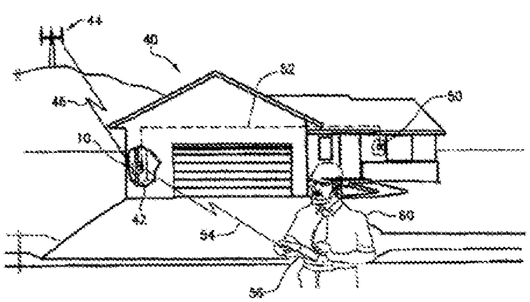
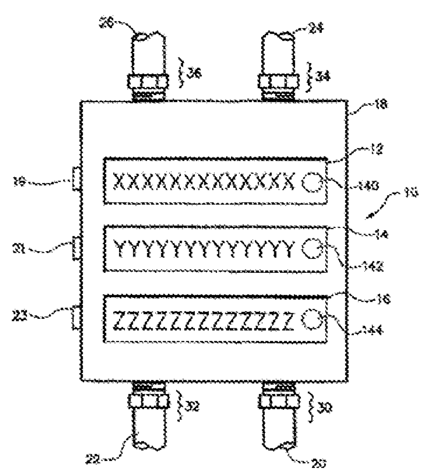
Primary Examiner — Matthew W Jellett
(74) *Attorney, Agent, or Firm* — Michael Edward Klicpera

(57) **ABSTRACT**

The present invention is a water use and/or a water energy use monitoring apparatus that is affixed to the hot and cold water supply piping for continuously (or on demand) monitoring displaying the water and water energy (hot vs. ambient) use within a residential or commercial building. The water use monitor apparatus includes a power generation, a microprocessor, temperature and water flow sensors, optional water quality sensors, timing circuits, wireless circuitry, and a display means. A wired or wireless means is designed to electronically communicate water use, water energy use and/or water quality information to a remotely located display apparatus or typical cell phone, smart phones, or similar apparatus for convenient observation by a commercial, operator or occupier, resident, municipal or government agency.

34 Claims, 11 Drawing Sheets





Related U.S. Application Data

a continuation-in-part of application No. 13/776,963, filed on Feb. 26, 2013, now Pat. No. 9,297,150, and a continuation-in-part of application No. 14/561,271, filed on Dec. 5, 2014, now Pat. No. 9,494,480.

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G01F 1/58	(2006.01)
G01F 1/66	(2006.01)
G01F 1/68	(2006.01)
G01F 1/84	(2006.01)

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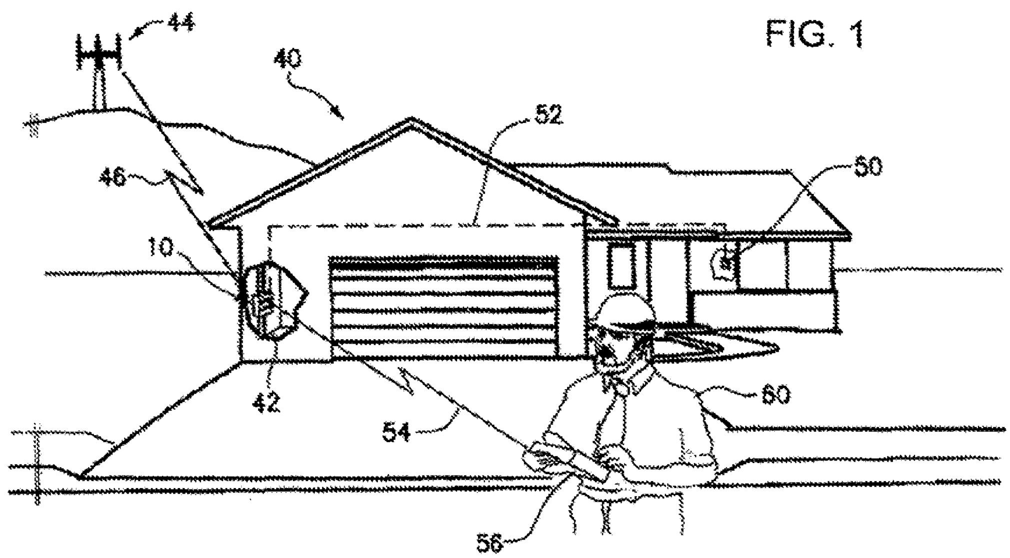
FIG. 1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42
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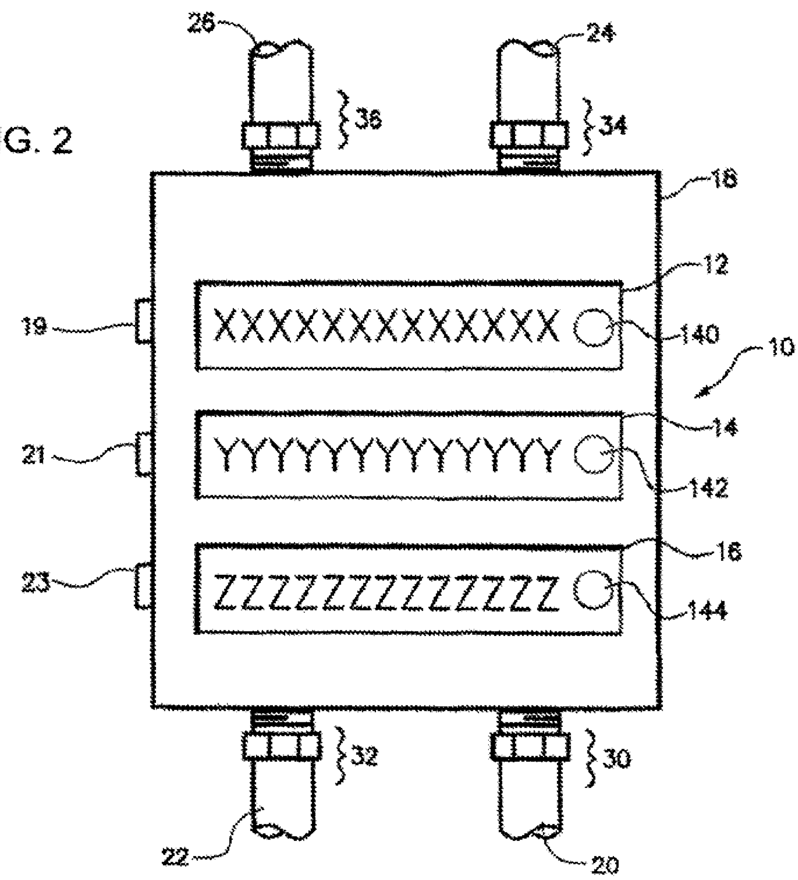
60
56

FIG. 2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24
36
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XXXXXXXXXXXXX
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10
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21
YYYYYYYYYYYYY
14
142
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ZZZZZZZZZZZZZ
16
144
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30
22
20

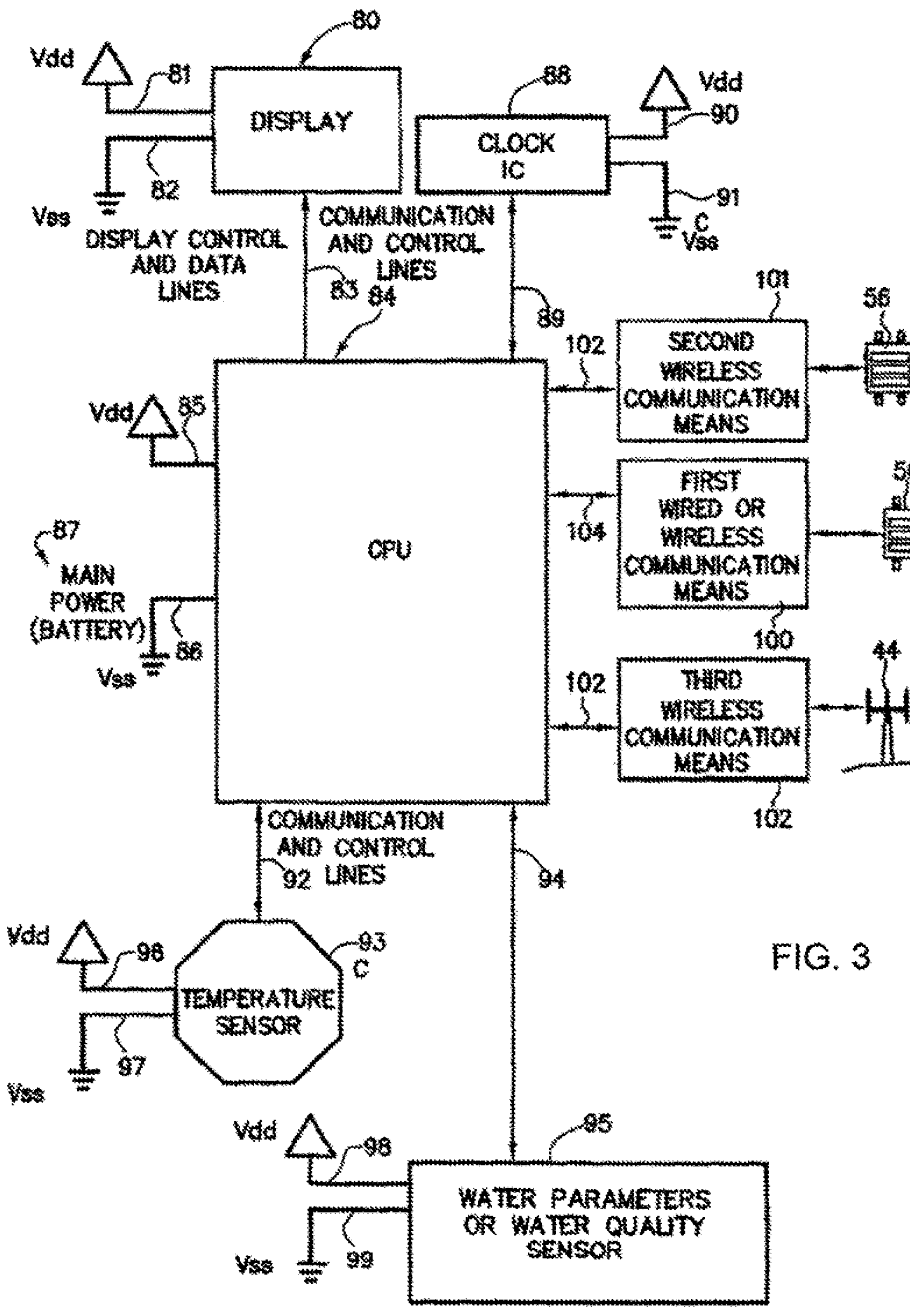
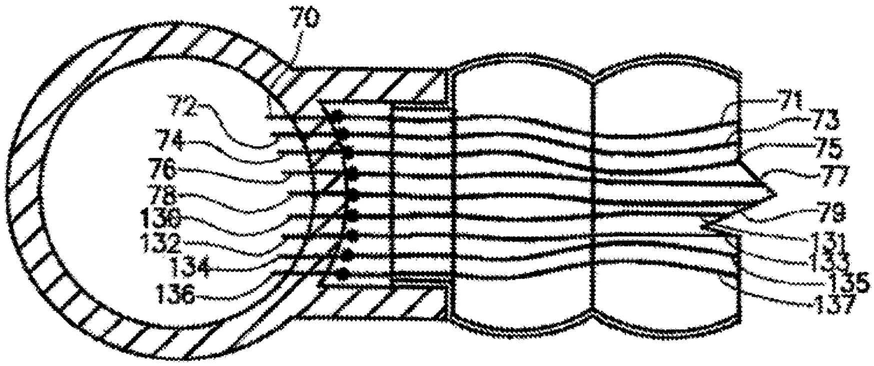

80
Vdd
81
DISPLAY
88
Vdd
CLOCK IC
90
82
91
Vss
DISPLAY CONTROL AND DATA LINES
COMMUNICATION AND CONTROL LINES
C
Vss
83
84
89
101
56
102
SECOND WIRELESS COMMUNICATION MEANS
Vdd
85
50
FIRST WIRED OR WIRELESS COMMUNICATION MEANS
87
104
CPU
MAIN POWER (BATTERY)
86
Vss
100
44
102
THIRD WIRELESS COMMUNICATION MEANS
102
COMMUNICATION AND CONTROL LINES
92
94
Vdd
96
93
C
TEMPERATURE SENSOR
97
Vss
Vdd
98
95
WATER PARAMETERS OR WATER QUALITY SENSOR
Vss
99

FIG. 3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131
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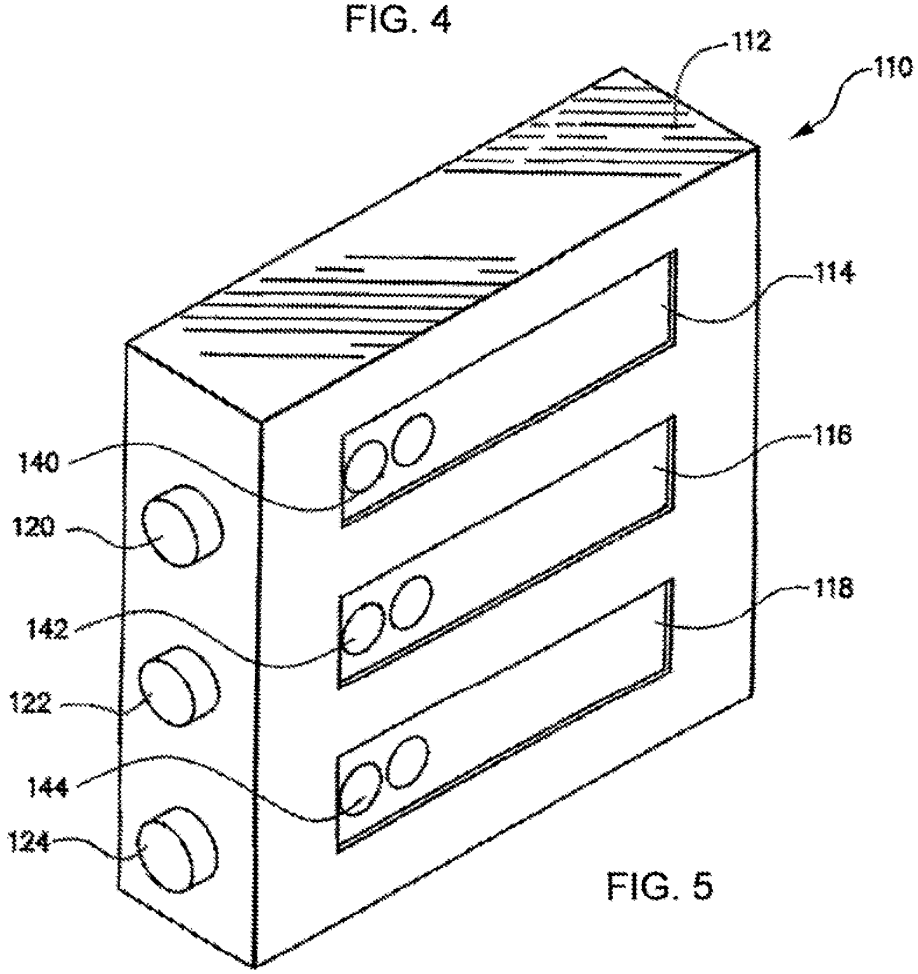
135
137

FIG. 4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116
118
140
120
142
122
144
124

FIG. 5

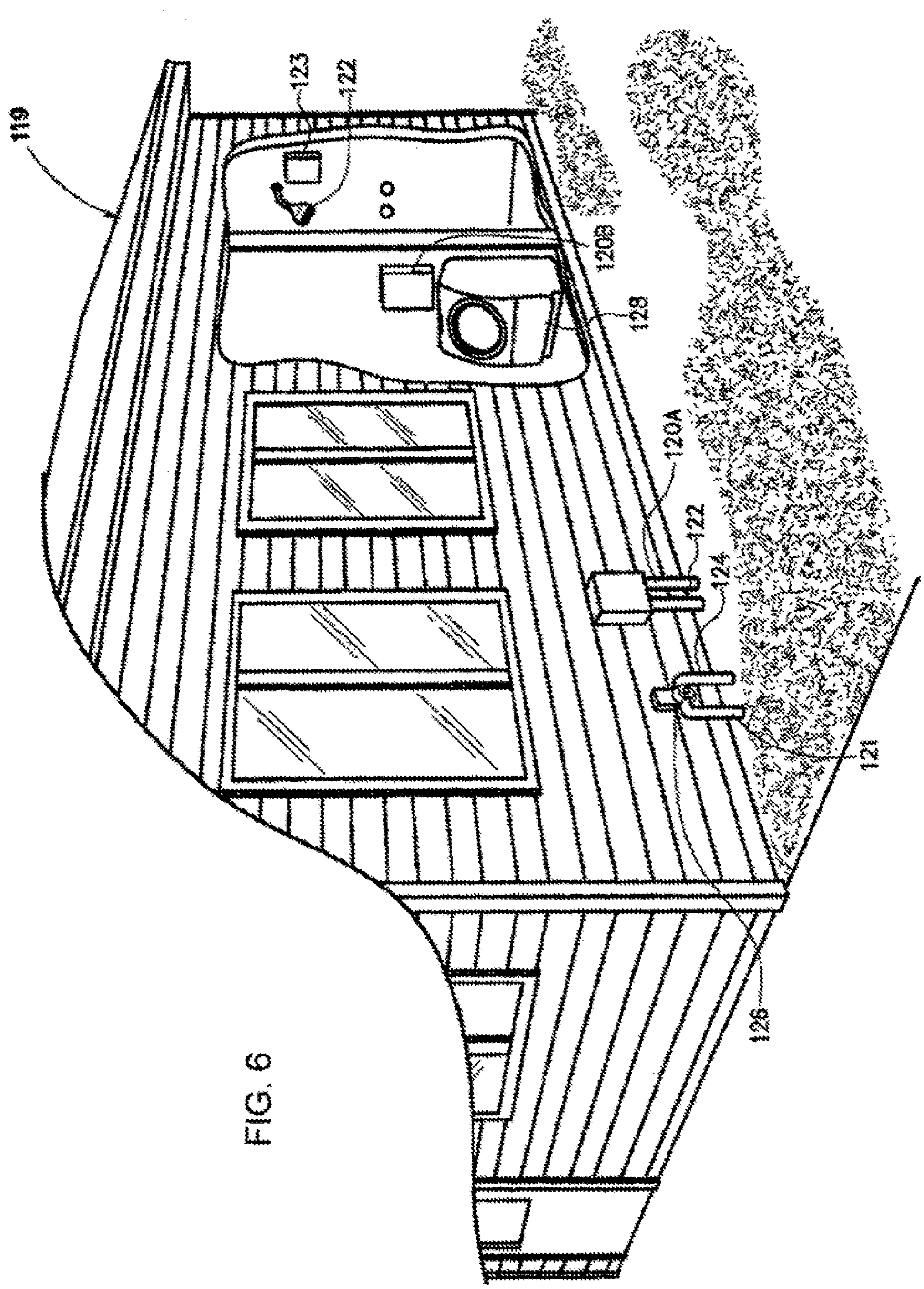


FIG. 6

Fig. 7

Water Use

Average Time:	10	minutes
Average Water Use:	9.5	liters/minute
Water Cost:	7.6	per 3785 liters

Water Heater Use

Energy Type	Natural Gas	
State	California	
Cost	2.043	per Therm
Efficiency	0.94	
Avg. Ambient Water Temp.	12.8	centigrade
Desired Shower Temperature	46.5	centigrade

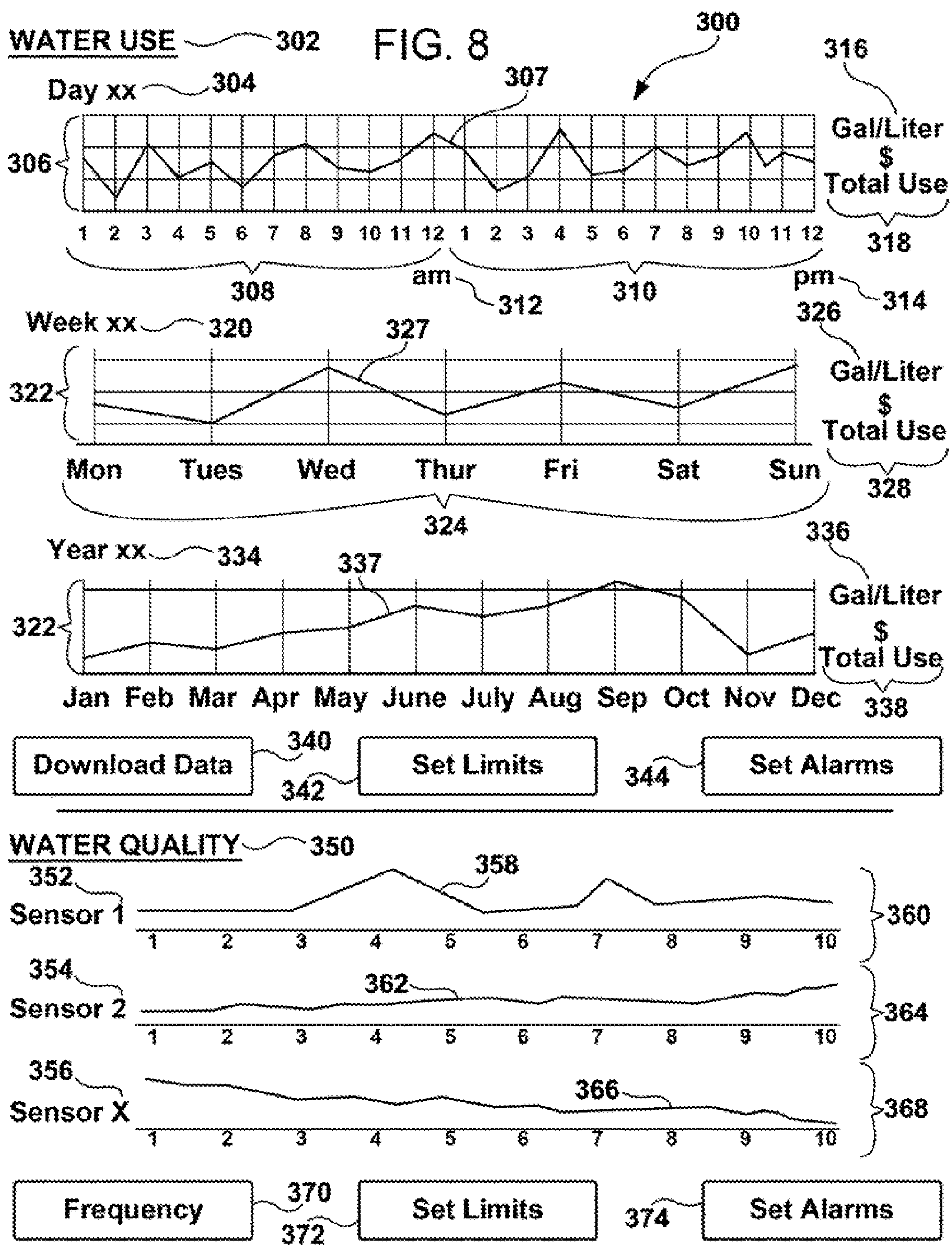
Water Use (liters)

	Day	Week	Month	Year	2 Year
Water	284	1988	8520	103660	207320
Energy	0.31	2.59	7.37	89.58	179.2

Water Cost (San Diego)

	Day	Week	Month	Year	2 Year
Water	$1.87	$13.1	$56.06	$682.6	$1365.1

FIG. 8



WATER USE
302
300
Day xx
304
307
316
306
Gal/Liter
$
Total Use
318
1 2 3 4 5 6 7 8 9 10 11 12 1 2 3 4 5 6 7 8 9 10 11 12
308
am
312
310
pm
314
Week xx
320
327
326
322
Gal/Liter
$
Total Use
Mon Tues Wed Thur Fri Sat Sun
328
324
Year xx
334
337
336
322
Gal/Liter
$
Total Use
Jan Feb Mar Apr May June July Aug Sep Oct Nov Dec
338
Download Data
340
342
Set Limits
344
Set Alarms
WATER QUALITY
350
352
Sensor 1
358
360
354
Sensor 2
362
364
356
Sensor X
366
368
1 2 3 4 5 6 7 8 9 10
Frequency
370
372
Set Limits
374
Set Alarms

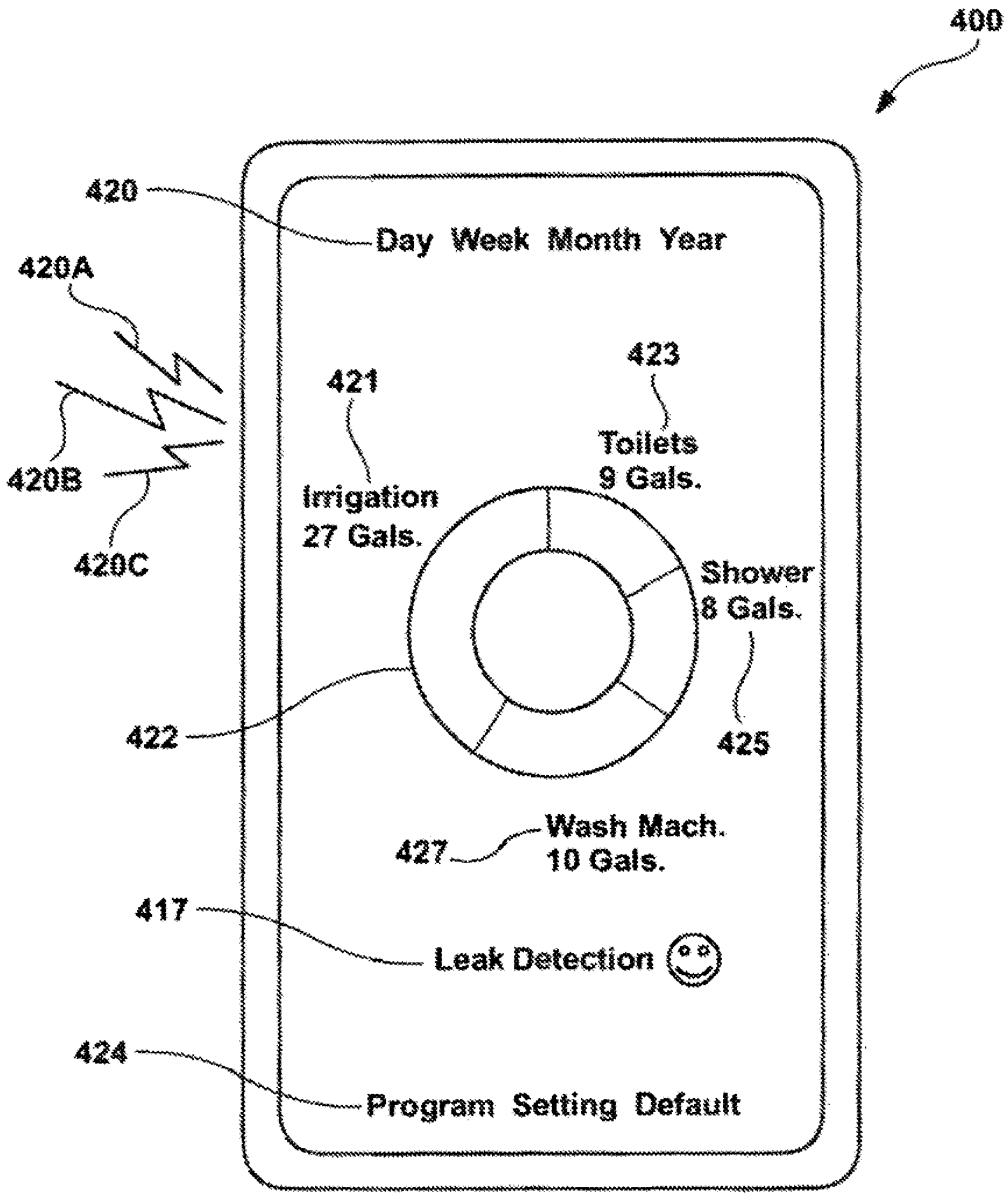

400
420
Day Week Month Year
420A
421
423
Toilets
9 Gals.
420B
Irrigation
27 Gals.
420C
Shower
8 Gals.
422
425
427
Wash Mach.
10 Gals.
417
Leak Detection
424
Program Setting Default

FIG. 9A

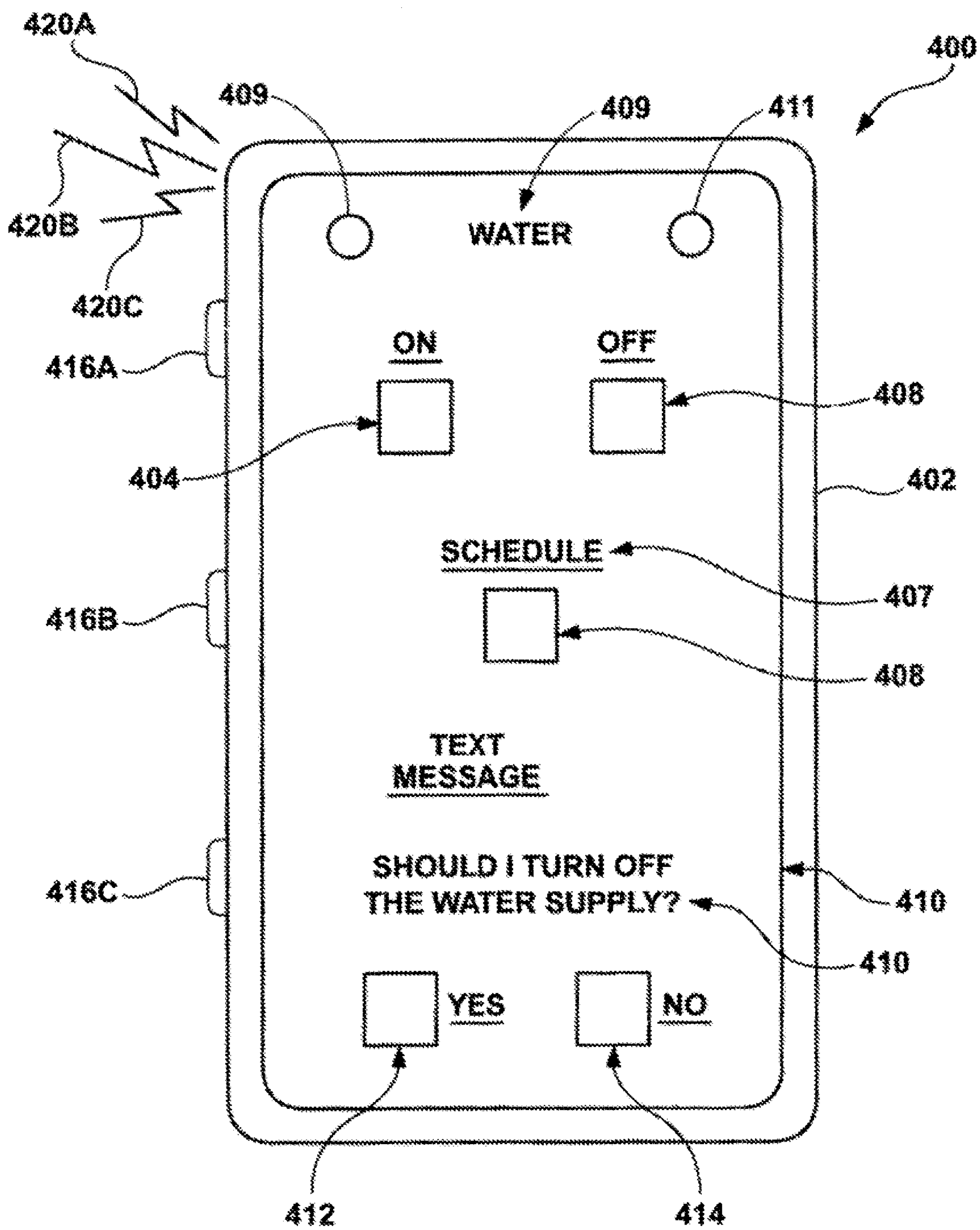

420A
400
409
409
411
WATER
420B
420C
416A
ON
OFF
408
404
402
SCHEDULE
407
416B
408
TEXT
MESSAGE
SHOULD I TURN OFF
THE WATER SUPPLY?
416C
410
410
YES
NO
412
414

FIG. 9B

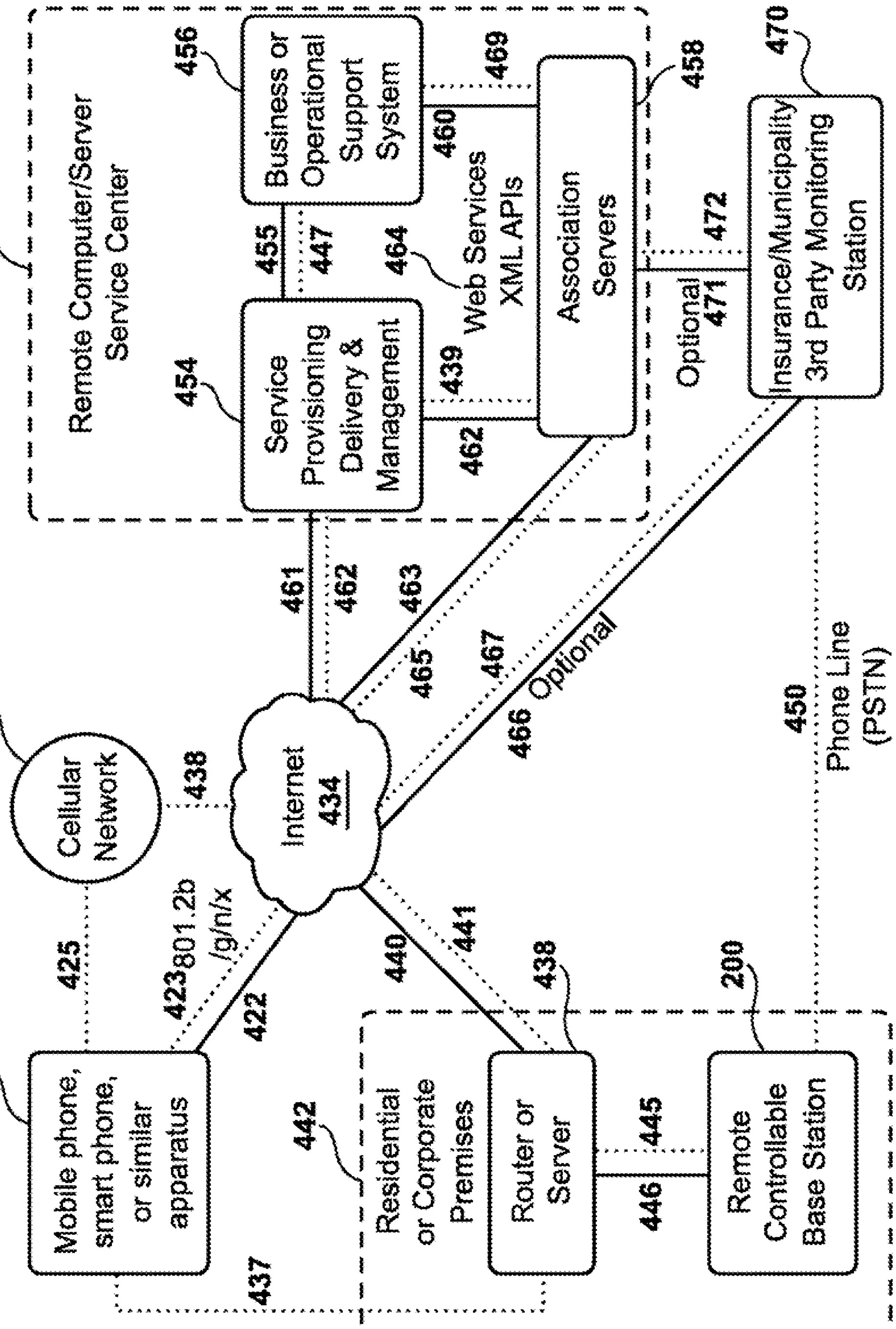

452
Remote Computer/Server Service Center
456
Business or Operational Support System
455
447
454
Service Provisioning Delivery & Management
464
Web Services XML APIs
460
469
439
462
Association Servers
458
470
Insurance/Municipality 3rd Party Monitoring Station
472
Optional
471
436
Cellular Network
438
Internet
434
461
462
463
465
467
466
Optional
450
Phone Line (PSTN)
400
Mobile phone, smart phone, or similar apparatus
425
423
801.2b /g/n/x
422
440
441
438
200
442
Residential or Corporate Premises
Router or Server
445
446
Remote Controllable Base Station
437

FIG. 10

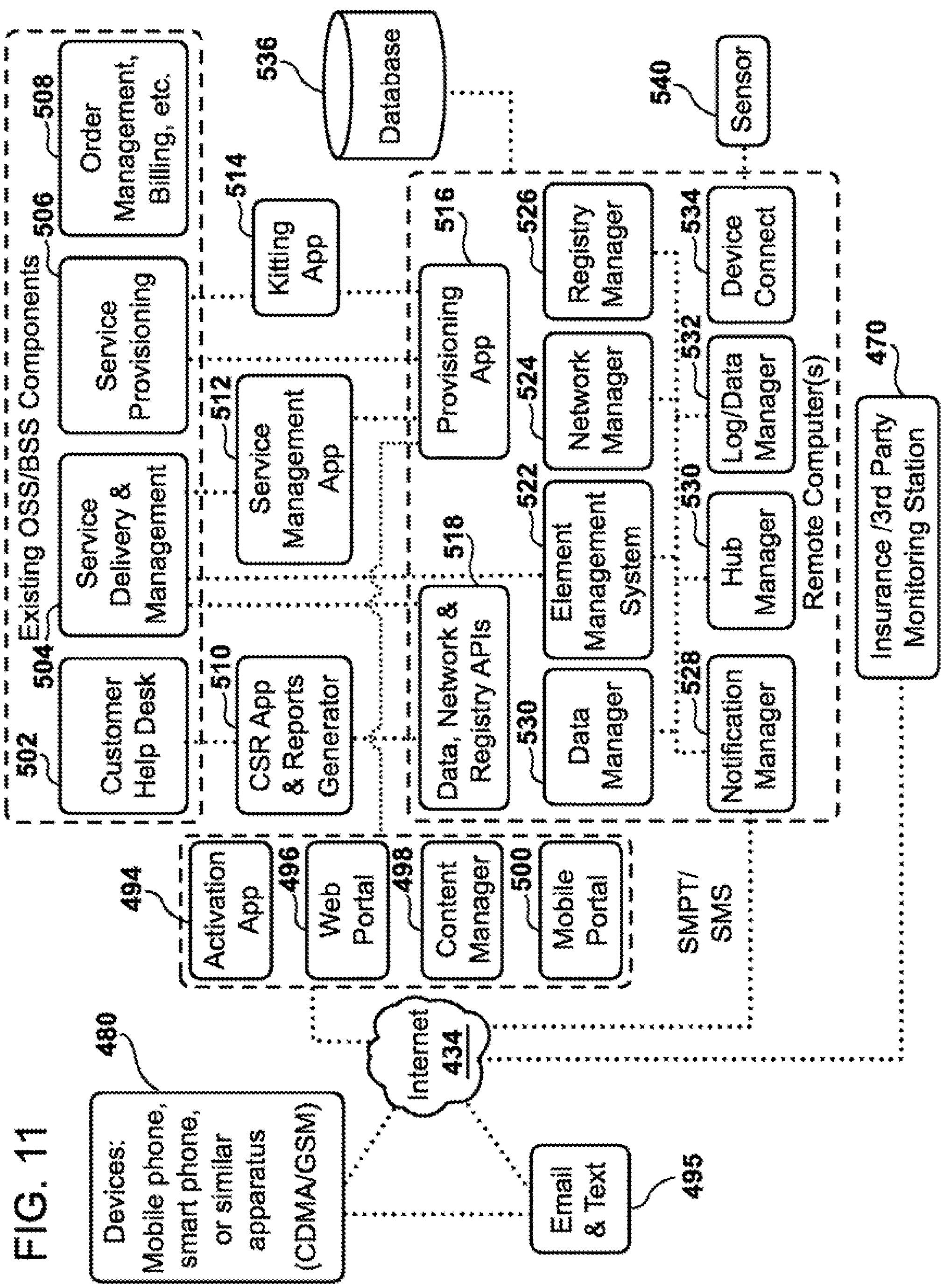
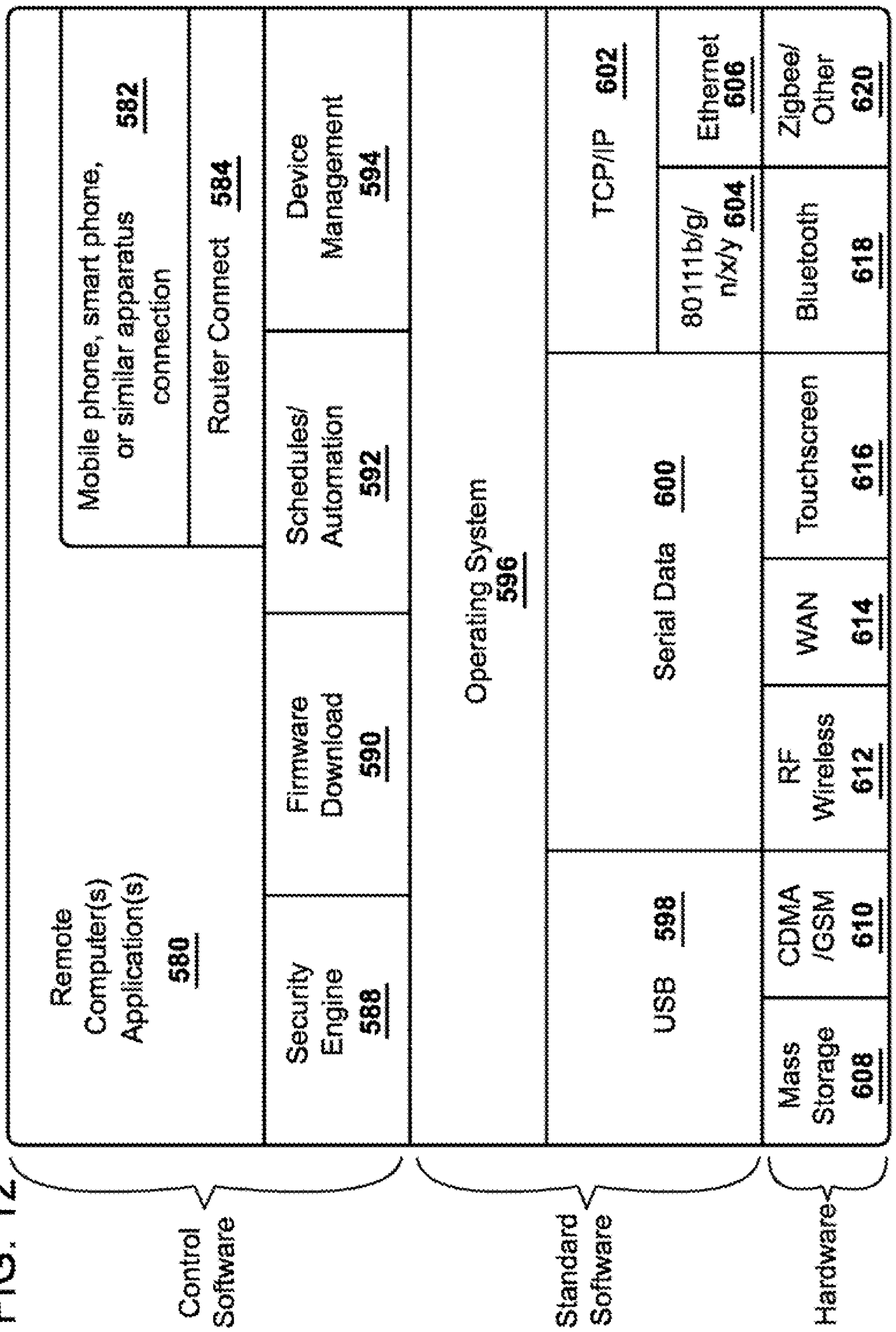

Existing OSS/BSS Components
502
Customer Help Desk
504
Service Delivery & Management
506
Service Provisioning
508
Order Management, Billing, etc.
510
CSR App & Reports Generator
512
Service Management App
514
Kitting App
536
Database
516
Provisioning App
518
Data, Network & Registry APIs
530
Data Manager
522
Element Management System
524
Network Manager
526
Registry Manager
528
Notification Manager
530
Hub Manager
532
Log/Data Manager
534
Device Connect
Remote Computer(s)
540
Sensor
470
Insurance /3rd Party Monitoring Station
494
Activation App
496
Web Portal
498
Content Manager
500
Mobile Portal
SMPT/ SMS
Internet
434
480
Devices: Mobile phone, smart phone, or similar apparatus (CDMA/GSM)
Email & Text
495

FIG. 11

FIG. 12


Remote Computer(s) Application(s) 580
Mobile phone, smart phone, or similar apparatus connection 582
Router Connect 584
Security Engine 588
Firmware Download 590
Schedules/ Automation 592
Device Management 594
Operating System 596
USB 598
Serial Data 600
TCP/IP 602
80111b/g/ n/x/y 604
Ethernet 606
Mass Storage 608
CDMA /GSM 610
RF Wireless 612
WAN 614
Touchscreen 616
Bluetooth 618
Zigbee/ Other 620
Control Software
Standard Software
Hardware

WATER USE MONITORING APPARATUS

RELATED APPLICATIONS

This Patent Application is a continuation-in-part of U.S. patent application Ser. No. 14/561,271 filed on Dec. 5, 2014, U.S. patent application Ser. No. 13/776,963 filed on Feb. 26, 2013, and U.S. patent application Ser. No. 12/539,150 filed on Aug. 11, 2009. All of these Patent Applications are incorporated herein by this reference in its entirety.

FIELD OF THE INVENTION

This apparatus and the method of use relates to a metering apparatus integrated with residential or commercial water supply piping, more particularly, relates to a water use with or without a water energy use monitoring apparatus. This apparatus has the capability of communicating with an optional remote display for viewing and recording within a residential or commercial building, and/or with an optional remote display for viewing or recording for a resident or company user/owner, government or municipal purposes.

BACKGROUND OF THE INVENTION

Water conservation is becoming a major issue for many cities, towns, and communities, and an apparatus for monitoring water and water energy uses at specific residential, corporate, (or government) sites could be useful in supporting water conservation and in assessing and controlling water resources.

Several municipalities are considering or have enacted water conservation laws or ordinances. For example, the city of San Diego, Calif. has considered enacting an ordinance requiring new multi-housing to include a secondary means for monitoring water use. Florida's Miami-Dade County Ordinance 08-14, effective on Jan. 1, 2009, defined restricted toilet, urinals, faucet and shower head water flow. California Assembly Bill 715 phases in lower flush volume requirements for water closets and urinals. Texas House Bill 2667 mandates showerhead ratings of <2.5 gallons per minutes and urinal flush volumes <0.5 gallons per flush. Los Angeles, Calif.'s High Efficiency Plumbing Fixtures Ordinance contains requirements to install high efficiency water fixtures for all new buildings and renovations.

For non-water related operations, the SmartMeter™ System, manufactured by GE and Landis+Gyr, collects electric and natural gas use data from a home or business. The SmartMetert™'s electric meter records and transfers residential electric use hourly, and commercial electric use in 15 minute increments. The SmartMeter™'s natural gas module(s) attached to a gas meters records daily gas use. The data collected by the SmartMeter™ is periodically transmitted via a secure wireless communication network. The SmartMeter™ system uses programmable solid-state meter technology that provides two-way communication between the meter at your home or business and the utility, using secure wireless network technology.

The solid-state digital Smart Meter™ electric meter records hourly meter reads and periodically transmits the reads via a dedicated radio frequency (RF) network back to a defined municipality. Each SmartMeter™ electric meter is equipped with a network radio, which transmits meter data to an electric network access point. The system uses RF mesh technology, which allows meters and other sensing devices to securely route data via nearby meters and relay devices, creating a "mesh" of network coverage. The system supports two-way communication between the meter and PG&E. SmartMeter™ electric meters can be upgraded remotely, providing the ability to implement future innovations easily and securely.

The electric network access point collects meter data from nearby electric meters and periodically transfers this data to defined municipality via a secure cellular network. Each RF mesh-enabled device (meters, relays) is connected to several other mesh-enabled devices, which function as signal repeaters, relaying the data to an access point. The access point device aggregates, encrypts, and sends the data back to the defined municipality over a secure commercial third-party network. The resulting RF mesh network can span large distances and reliably transmit data over rough or difficult terrain. If a meter or other transmitter drops out of the network, its neighbors find another route. The mesh continually optimizes routing to ensure information is passed from its source to its destination as quickly and efficiently as possible.

Most residential and commercial water supply lines have a primary water meter. However, the location of the primary water meter is usually not readily available or not in a convenient location for a commercial owner or occupier, or a resident to observe. Even if the primary water meter is available for review by a commercial owner or occupier, or resident, the display is a simple continuous or cumulative gauge that does not allow the reader to readily monitor their daily, weekly, monthly, and annual water uses. Furthermore, the primary water meter does not have the capability to wirelessly transfer water use information to a remote display (or recorder with data collection/database) that is conveniently located for review by the owner or occupant of a residence or building to encourage water conservation. In addition, the primary water meter only monitors commercial or residential supply water, and there is no capability to analyze hot and/or cold water use to provide water energy use information or distinguish between indoor and outdoor water use.

Accordingly, a need remains for a primary or secondary water monitor that is conveniently located in a commercial or residential setting and provides readily available water use in a format for encouraging water conservation.

Further accordingly, a need remains for a primary or secondary water monitor that is conveniently located in a commercial or residential setting that has wireless capability for displaying water use information to a remote display that is suitably located for observation by a commercial operator or occupier, or resident.

Further accordingly, a need remains for a primary or secondary water monitor that is conveniently located in a commercial or residential setting that has wireless capability for displaying and recording water use information for governmental or municipal operators or agencies.

Further accordingly, a need remains for a primary or secondary water monitor that is conveniently installed in a commercial or residential water supply line that captures hot and/or cold water use and can provide water energy calculation(s).

Further accordingly, a need remains for a primary or secondary water monitor that is installed in a commercial or residential water supply line that independently captures indoor and outdoor water use.

Further accordingly, a need remains for a primary or secondary water monitor that is conveniently installed in a commercial or residential water supply line that monitors for leaking conditions and can communicate this alarming situ-

ation by wireless communication to an owner or occupant of a residence or commercial building.

SUMMARY OF THE INVENTION

The present invention comprises a water use and water energy use monitoring display apparatus having a base station attached to a water supply with wireless or wire capability to communicate with one or more remote display and for recording apparatus devices. More specifically the present invention is a water use and/or a water energy use monitoring apparatus base station that is affixed to the water supply piping (connected to either connected to the cold and hot water supply lines) for continuous, or on demand, monitoring the water and water energy (hot vs. ambient) or in another embodiment the single water supply line used within a residential or commercial building. In addition, the present invention could be used with non-commercial water sources such as private wells and other non-commercial water sources. The water use and water energy use monitoring display apparatus base station can optionally have a display means for displaying a plurality of water parameters. A first wire or wireless means is incorporated to a remote display and/or recording display for viewing water parameter data by the commercial owner, occupier or home/apartment/condominium resident. A second wire or wireless means is designed for monitoring and recording water parameter data by civil, commercial, governmental or municipal operators or agencies, using a remote display and/or recorder means connected by a secure wire or wireless communication network. A third wireless communication means is designed to use cellular format technology to transmit water and water energy parameter data to a remote location. The housing of the water use monitor apparatus base station or the display/recording remotes can be fabricated from materials (e.g. a polymeric or metallic or any combination and possibly include chrome, brass white or colored finishes or combination of these finishes and materials of construction). The water use monitor apparatus base station includes a power generation, a microprocessor, temperature sensor, water flow sensor and optional water quality sensors, optional high sensitive water flow sensor for detecting leaking conditions and providing a separate data for indoor and outdoor water use, timing circuits, wireless circuitry, and an optional display means. Ergonomically placed buttons or touch screen technology can be integrated with this optional display as the base station or the display and recording remotes to change parameter units (e.g. metric to US), set alarm conditions (e.g. volume set points), calibrate sensors, and program features (e.g. change the language, input a cell, mobile or standard telephone number for certain communications). A first wired or wireless means is designed to electronically communicate the water use and/or water energy use information to a remotely located display for convenient observation by a commercial operator or occupier, or home/apartment/condominium resident. A secondary wireless means is designed to electronically and wirelessly communicate water and water energy use information to governmental or municipal operators or agencies. A third wireless means is designed for communicating to an offsite central monitoring computer or cell, mobile or other telephone lines via satellite, microwave technology, the internet, cell tower, telephone lines, and the like to a governmental or municipal operator or a residential or corporate owner.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a perspective view of the embodiment comprising the water use and water energy use monitoring display apparatus base station affixed to the input cold and hot water supply piping for continuously monitoring of the water and energy use within a residential or commercial building. Also shown in FIG. **1** is the optional wireless or wired capability of the water use and a water energy use monitoring apparatus for communicating water use and water energy use information to a conveniently located remote display/recorder for the commercial operator or occupier or residential individual and an optional display/recorder for a governmental, civil, commercial or municipal operators or agencies. In addition, FIG. **1** also shows a wireless means for communicating to an offsite central monitoring computer or cell, mobile or other telephone lines via satellite, microwave technology, the internet, cell tower, telephone lines, and the like.

FIG. **2** is a front view of a water use and water energy use monitoring apparatus base station showing input hot and cold water supplies lines and output hot and cold water supply lines with optional display means having one or more display screens and a plurality of hardware and/or software buttons.

FIG. **3** is an electrical schematic showing the main power, CPU or microprocessor, the analog or digital display means, the timing circuit, the temperature sensor, and the flow sensor.

FIG. **4** is a cross-section perspective view showing a plurality of water parameter sensors located in relative positions within the supply line lumen and the connecting wires.

FIG. **5** is a perspective view of the first or second or third display/recording remote having a plurality of display means and a plurality of hardware and/or software buttons.

FIG. **6** is a perspective view of a plurality of high sensitive water flow sensors including a transceiver that is attached to various locations of a typical house for monitoring indoor water use and leak detection.

FIG. **7** is an example of a water energy data format that uses cold/ambient water and hot water to provide water usage and water energy costs.

FIG. **8** is a perspective view of a first application (APP), or a first page of a application (APP), displayed on a typical cell phone, smart phone or similar apparatus.

FIG. **9A** is a perspective view of a typical cell phone, smart phone or similar apparatus having a third application (APP), or a third page of a (APP), programmed to displaying the soft buttons to determine the period for displaying, graphical of water use devices, leak detection graphical item, and programming/setting soft buttons.

FIG. **9B** is a perspective view of a typical cell phone, smart phone or similar apparatus having a second application (APP), or a second page of a (APP), programmed to display soft buttons or control activator.

FIG. **10** is a block diagram of the more integrated system.

FIG. **11** is a block diagram of components of the more integrated system

FIG. **12** is a block diagram of the more integrated software and applications.

Corresponding reference characters indicate corresponding parts throughout the several views. The exemplifications set out herein illustrate example embodiments of the inven-

tion, and such exemplifications are not to be construed as limiting the scope of the invention in any manner.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Definitions of word or phrases to be used herein are presented below:

Water Use refers to the total volume of water used over a period of time.

Water Energy Use refers to the ratio of cold or ambient water to heated water use or to the ratio of hot water to total water use or as further defined herein.

Residential and Commercial operations refer to multi-unit apartment buildings, condominiums, hospitals, dormitories, commercial office buildings, homes, and the like.

Encryption refers to a privacy technology that prevents anyone but the intended recipient(s) to download, review or read confidential information and data.

Authentication refers to the technology that ensures that a message, data or information that is downloaded or transferred from a one person or device to another declared or intended person or device.

Integrity refers to technology that ensures that a message, information or data does not alter in any way during transit.

Non-repudiation refers to the technology that prevents a sender from denying that a message, data or information was sent.

Cellular format technology refers to all current and future variants, revisions and generations (e.g. third generation (3G), fourth generation (4G), fifth generation (5G) and all future generations) of Global System for Mobile Communication (GSM), General Packet Radio Service (GPSR), Code Division Multiple Access (CDMA), Evolution-Data Optimized (EV-DO), Enhanced Data Rates for GSM Evolution (EDGE), 3GSM, Digital Enhanced Cordless Telecommunications (DECT), Digital AMPS (IS-136/TDMA, Integrated Digital Enhance Network (iDEN), HSPA+, WiMAX, LTE, Flash-OFDM, HIPERMAN, WiFi, IBurst, UMTS, W-CDMA, HSPDA+HSUPA, UMTS-TDD and other formats for utilizing cell phone technology, antenna distributions and/or any combinations thereof, and including the use of satellite, microwave technology, the internet, cell tower, and/or telephone lines.

A typical cell phone, smart phones, or other electronic apparatus includes all remote cellular phones using channel access methods defined above (with cellular equipment, public switched telephone network lines, satellite, tower and mesh technology), mobile phones, PDAs, tablets (e.g. refers to all current and future variants, revisions and generations of the APPLE®, SAMSUNG®, HP®, ACER®, MICROSOFT®, NOOK®, GOOGLE®, SONY®, KINDLE® and other tablets manufactured by these and other manufactures), APPLE TOUCH®, a smart or internet capable television, wireless timepiece or watch (APPLE®, SAMSUNG®) and other electronic apparatus with WIFI and wireless capability, and remote computers and controllers having internet, wireless and/or cell format technology connectivity.

Geo-fencing generally refers to a radius around a home, corporation or point location or can be a predefined set of boundaries, like school attendance zones or neighborhood boundaries. When a device having geo-fencing technology of a location-based service enters or exits a geo-fence area, the device receives a generated notification of such entrance, exit or movement. This notification might contain specific information about the location of the device or simply utilized the location information to a remote apparatus. The device having geo-fencing generally uses GPS (global positional system) for location determination but with multiple cell towers servicing a cell phone, smart phone or similar apparatus, the multiple cell towers format can utilize triangulation or multi-lateration of radio signals between (several) radio towers of the network and the phone. To locate the phone using multi-lateration of radio signals, it must emit at least one other signal (roaming) to contact the next nearby antenna or cell tower and this location process does not require an active call. GSM cell phone technology is based on the signal strength to nearby antennas. The technology of locating is based on measuring power levels and antenna patterns and uses the concept that a powered mobile phone always communicates wirelessly with one of the closest base stations, so knowledge of the location of the base station implies the cell phone is nearby. Advanced systems determine the sector in which the mobile phone resides and roughly estimate also the distance to the base station. Further approximation can be done by interpolating signals between adjacent antenna towers. Geo-fencing processes may achieve a precision of down to 25-75 feet in urban areas where mobile traffic and density of antenna towers is sufficiently high whereas. Rural and desolate areas may see miles between base stations and therefore determine locations is obviously less precise. Wifi data can also be used to identify a cell phone, smart phone or similar apparatus location. Indoor environment creates problems and has poor performance of the GPS-based methods whereas WiFi technology is designed to provide another method to provide location of Geo-fencing technology. Many current cell phones, smart phones and similar apparatus combine GPS with Wi-Fi for both active calling and positioning systems. When a device with geo-fencing technology exist or enters a defined area, a notice might be sent to a cell phone, smart phone or similar apparatus, to an email account, to a text (SMS), or to perform a or software operation. Geo-fencing allows users of the system to draw zones around places of residence or corporations, customer's sites and secure areas.

The term "water use" apparatus generally refers to apparatuses that are connected to a water supply and have a water control valve or flow control mechanism to turn on and off the water supply, such as irrigation valves and systems, hot water heaters, washing machines, dishwashers, kitchen faucets, bathroom faucets, showers, toilets, refrigerators with water supply and ice makers, Jacuzzi and pools with water supplies, decorative fountains, any other water use devices.

There are two embodiments shown in the drawings and described in the specification. The first embodiment is a water use and water energy monitoring apparatus having a base station **10** that is positioned in close proximity to the hot and cold or ambient water supply. The second embodiment is a water use monitoring apparatus has a base station **126** that is positioned in close proximity to only the cold or ambient water supply and not to the hot water supply. Many of the features, characteristics and components described in this specification are common between the apparatus **10** and apparatus **126** and hence are interchangeable. In the regard and in an effort to minimize redundancy, many of the common features, characteristics and components are referenced commonly as apparatus **10**, **126**.

Referring now to the drawings and particularly to FIG. **1** is a perspective view of the first embodiment comprising the comprising the water use monitoring display apparatus base station **10** affixed to the hot and cold (see second embodiment **126** in FIG. **6**) water supply piping in an appropriate location for water monitoring **42** and for continuously

monitoring of the water and water energy use within a residential or commercial building **40**. This can be useful for an individual or commercial operator employing water conservation methods (e.g. reduce the sprinkler frequency or duration, encourage individuals to take shorter showers, fix leaking devices). Alternately, the monitoring of indoor water use and outdoor water use could be utilized by the particular water supplying municipality or government agency to apply different rates for indoor water use and outdoor water use. In addition, since many municipal agencies include a sewer cost in a ratio of the total supply use, the difference between indoor water use and outdoor water use can reduced the total sewer cost associated with only the indoor use, thus saving the consumer costs. In certain situations, a control valve can be located at a particular location, e.g. the irrigation valve or ball valve whereby by utilizing the two-way wireless capability of the present invention apparatus **10**, **126** whereby the owner, water supplying municipality or government agency can remotely control water use (e.g. turn the main water supply off after a leaking notice, send out a code that inhibits outdoor water use on certain days or at certain hours of the day). For accurate measurements of water use or water energy use the present invention should be installed between the pressure reducing valve or civil, commercial, governmental or municipal supply water sources (with potential meter) and/or any distribution lines. It is also anticipated by the Applicant that present invention can be used on wells and in situations where the water source is not obtained from a commercial or municipal operations. The water use and water energy use monitoring apparatus base station **10**, **126** can update, upload or download water and energy use on various frequencies, e.g. once per minute, once per hour, once per day, or can send information upon sensing the initiation of water use (after no water use period) on the display/recorder screen (shown in FIG. **2**).

Also shown in FIG. **1** is a first wired or wireless communication means **52** from the water use and water energy use monitoring apparatus base station **10**, **126** for communicating water use and water energy use information or data to a conveniently located first display and/or recorder apparatus **50** (defined in more detail in FIG. **5**) located in a convenient location for the commercial operator or occupier or residential individual to observe daily, weekly, monthly or annual water use. The water use and water energy use monitoring apparatus base station **10**, **126** can be programmed to communicate at other time frequencies, such as every 5 seconds or every minute, for various purposes, for example, to identify leaking conditions. The first wireless communication means **52** preferably utilizes encryption, authentic, integrity and non-repudiate techniques to provide a secure transfer of the water and energy use from the water/energy use from the monitoring base station apparatus **10**, **126** to the first remote and/or recorder **50**. The first wired or wireless communication means **52** can send data on various frequencies, e.g. once per minute, once per hour, once per day, or can send information upon sensing an initiation to the first remote and/or recorder **50** or atypical cell phone, smart phones, or similar apparatus (see FIG. **9**). Furthermore, the first wired or wireless communication means **52** can send data or information upon the sending of a request signal. The request signal can be generated by, for example, the pushing of a requesting button located on the first remote display and/or recorder **50** that transmits a request for water and energy use data to the water and energy monitoring apparatus base station **10**, **126**. The use of the request signal can minimize the use of wireless signals within the house or commercial building, conserving energy, minimizing the interference with other wireless devices, and reduce the exposure of wireless energy to individuals. Furthermore, the first wireless communication means **52** can consist of two-way transmission, commonly known as transceiver technology, such that the monitoring display apparatus base station **10**, **126** can transmit and receive electronic signals from the first display and/or recording apparatus **50** and similarly, and the first display and/or recording apparatus **50** can transmit and receive electronic signals from the monitoring display apparatus base station **10**, **126**. The first wired or wireless communication **52** can be either one-way transmission, or half duplex and/or full duplex two-way transmission.

The second optional wireless communication means **54** is preferred to transit, upload or download water parameter data or information via a secure wireless communication network providing information to a governmental, civil or municipal employee or individual **60** using a second remote display and/or recorder apparatus **56** (or a typical cell phone, smart phones, or similar apparatus as shown in FIG. **9**) for property owners, governmental, civil, commercial or municipal operators or agencies purposes. It is anticipated that the second wireless communication means **54** can also be received by a moving vehicle or can communicate with cellular format technology utilizing cell towers **44** using another third wireless communication **46**. The second optional wireless communication means **54** preferably utilizes encryption, authentic, integrity and non-repudiate techniques to provide a secure transfer of the water and energy use from the water monitoring display base station **10**, **126** to the second remote display and/or recorder apparatus **56**. Also, the second wireless communication means **54** should include specific identification information e.g. house or commercial building address, IP address or other specific technology. The second optional wireless communication means **56** can send data on various frequencies, e.g. once per minute, once per hour, once per day, or can send information upon sensing an initiation to the second remote and/or recorder **56**. The water use and water energy use monitoring apparatus base station **10**, **126** can be programmed to communicate at other time frequencies, such as every 5 seconds or every minute, for various purposes, for example, to identify leaking conditions. Furthermore, the second optional wireless **56** communication means can send data or information upon the sending of a request signal. The request signal can be generated by, for example, the pushing of a requesting button located on the second remote display and/or recorder **56** that transmits a request for water and energy use data to the water and energy monitoring apparatus base station **10**, **126**. The use of the request signal can minimize the use of wireless signals within the house or commercial building, conserving energy, minimizing the interference with other wireless devices, and reduce the exposure of wireless energy to individuals. Furthermore, the second wireless communication means **54** can consist of two-way transmission, commonly known as transceiver technology, such that the monitoring display apparatus base station **10**, **126** can transmit and receive electronic signals from the second optional display and/or recording apparatus **56** and similarly, and the second optional display and/or recording apparatus can transmit and receive electronic signals from the monitoring display apparatus base station **10**, **126**. Hence, the second optional wireless communication means **46** can be either one-way transmission, or half duplex and/or full duplex two-way transmission.

The third optional wireless communication means **46** is designed to communicate data under a cellular format technology with offsite central monitoring computer or cell, mobile or other telephone lines via satellite, microwave technology, the internet, cell tower, telephone lines, and the like. It is anticipated that the third wireless communication means **46** can transmit information to a programmed cell or phone number for communicating water parameter data or alarm situations to the owner or a municipal/governmental agency (such as announcing a water leak situation). Also, the third wireless communication means **46** should include specific identification information e.g. house or commercial building address, IP address or other specific technology. The third wireless communication means **46** can send data on various frequencies, e.g. once per minute, once per hour, once per day, or can send information upon sensing the initiation (alarm situation) to the programmed cell or phone number. The water use and water energy use monitoring apparatus base station **10**, **126** can be programmed to communicate at other time frequencies, such as every 5 seconds or every minute, for various purposes, for example, to identify leaking conditions. The request signal can be generated by, for example, a request signal transmitted by a remote station (not shown). The use of the request signal can minimize the use of wireless signals within the house or commercial building, conserving energy, minimizing the interference with other wireless devices, and reduce the exposure of wireless energy to individuals. Furthermore, the third wireless communication means **46** can consist of two-way transmission, commonly known as transceiver technology, such that the monitoring display apparatus base station **10**, **126** can transmit and receive electronic signals from the remote station and similarly, the remote station can transmit and receive electronic signals from the water use and water energy use monitoring display apparatus base station **10**, **126**. The third wireless means **46** can also be designed for communicating to an offsite central monitoring computer or cell, mobile or other telephone lines via satellite, microwave technology, the internet, cell tower, telephone lines, and the like. The third communication means **46** can also comprise a RF mesh-enabled device (meters, relays) is connected to several other mesh-enabled devices, which function as signal repeaters, relaying the data to an access point. The access point device aggregates, encrypts, and sends the data back to a municipal or government agency over a secure commercial third-party network. The resulting RF mesh network can span large distances and reliably transmit data over rough or difficult terrain. If a meter or other transmitter drops out of the network, its neighbors find another route. The mesh continually optimizes routing to ensure information is passed from its source to its destination as quickly and efficiently as possible. Furthermore, it is anticipated that the third wireless means can "piggy back" or be designed to be incorporated into and/or cooperation with electric and gas smart meters communication/transmission mesh technology. This takes advantage of the communication/transmission mesh means already in place thereby, minimizes cross talk and cross interference in wireless transmissions, and minimized overall wireless signals in residential or commercial area. The terminal communication/transmission of water parameter data can designed to be sent to a difference source, e.g. water municipality versus the electric or gas company. The third optional wireless communication can be either one-way transmission, or half duplex and/or full duplex two-way transmission. This third wireless technology **46** is designed for long range uses that can communicate with remote computers, for example, property owners, municipal and government uses, control, and billing practices. It is anticipated that the billing practices can be conducted by an independent corporate entity. This third wireless technology **46** can also be used to communicate with a home resident or corporate individual on their typical cell phone, smart phones, or similar apparatus **400** (see FIG. **9**).

Of all smart meter technologies, one critical technological problems of the present invention is secure data communication. Each base station **10**, **126** must be able to reliably and securely communicate the information collected to some central location. Considering the varying environments and locations where present invention meters are found, that problem can be daunting. Among the solutions proposed are: the use of cell phone/pager networks, satellite, licensed radio combination licensed and unlicensed radio, and power line communication. Not only the medium used for communication purposes but the type of network used is also critical. As such one would find: fixed wireless, mesh network or a combination of the two. There are several other potential network configurations possible, including the use of Wi-Fi and other internet related networks. To date no one solution seems to be optimal for all applications. Rural municipalities have very different communication problems from urban utilities or utilities located in difficult locations such as mountainous regions or areas ill-served by wireless and internet companies.

There is a growing trend towards the use of TCP/IP technology as a common communication platform for the present invention applications, so that utilities can deploy multiple communication systems, while using IP technology as a common management platform. Other solutions suggest the use of a single, universal connector separating the function of the smart grid device and its communication module. A universal metering interface would allow for development and mass production of smart meters and smart grid devices prior to the communication standards being set, and then for the relevant communication modules to be easily added or switched when they are. This would lower the risk of investing in the wrong standard as well as permit a single product to be used globally even if regional communication standards vary. The cellular format technology or other communication means can be used to transfer or download water parameter data from a residence/commercial operation, or well operation, to a remote monitoring site, or used to upload data, information or software updates to the water use and water energy use monitoring display apparatus **10**, **126**. In addition, the water leak monitoring capability of the present invention, described below, can use the cell tower or other communication means to communicate an alarm or message that a leak has developed in the residential/commercial or well water system. This leak identification means can call either a programmed cell or phone number, or can send the alarm or message to a governing utility or municipality. Digital signals and data can be communicated directly through wiring or wireless means **46**, **52**, and **54**.

The water sensors and/or water parameter sensors can transmit analog or digital data that is communicated either through direct wiring or through a wireless means **46**, **52**, and **54**. Amplification may be necessary by a circuit and then communicated directly to the microprocessor **84** or through one of the analog-to-digital modules if necessary. Remote display and/or a recording apparatus **50** (which is shown in more detail as **110** in FIG. **5**) has the relatively important function of providing an individual or entity to review water use and water parameter data for auditing or monitoring

purposes. It is also anticipated by the Applicants that the display means **12**, **14**, and **16** (shown in FIG. **2**) can be located remotely from the water use base station **10**, **126** containing the CPU or microprocessor **84** with communication and control lines **83** (shown in FIG. **3**) that communicate either wired or wirelessly. In addition, typical cell phones, smart phones and similar apparatus can be located remotely from the water use base station **10**, **126** containing the CPU or microprocessor **84** with communication and control lines **83** (shown in FIG. **3**) that communicate wirelessly. Hence, the communication and control lines **83** can be used to transfer water use and water parameters to a remotely positioned display receiver apparatus (not shown) or the display means **12**, **14**, and **16** can be eliminated to be replaced by the first display and/or recording apparatus **50**, **110** or typical cell phone, smart phone or similar apparatus. The first wireless communication means **52**, the optional second and third wireless communication means **46** and **56**, and the optional wireless communication and control lines **83**, can use radio-frequency, Bluetooth, ZigBee WiFi, optical or other wireless technology for transferring the water parameter data generated by the sensors and collected by the microprocessor and sent to a wireless to a display means and/or a remotely positioned receiver apparatus. Examples of Bluetooth modules (using the 2.4 GHz band as WiFi) that can be added to the present invention are the RN-41 Bluetooth modules available from Roving Networks in Los Gatos, Calif., the KC-41, KC 11.4, KC-5100, KC-216 or KC-225 data serial modules from KC Wireless in Tempe Ariz., and/or the BT-21 module from Amp'ed RF wireless solutions in San Jose, Calif. Examples of wireless protocols that can be utilized with the present invention include, but are not limited to, the IEEE 802.11a, IEEE 802.11b, IEEE 802.11g and IEEE 802.11n modulation techniques. Another example of the wireless protocols that can be utilized with the present invention is the ZigBee, Z-wave and IEE 802.15.4 modulation technology. Applicants recognize that there are numerous wireless protocols that have been developed that, although not specifically listed, could be utilized with the present invention for data transfer purposes.

In addition, the wireless or wire data transfer **46**, **52** and **56** (and **83**) can be connected to the Internet using the IP or DHCP protocols whereby the data can be monitored remotely over the Internet using a software program designed to record, display, analyze and/or audit the water parameter data. The present invention would probably have to "log on" to a server to report the water parameters or it could respond to queries once its presence is known to the server.

Also some wireless routers support a form of "private" point-to-point or bridging operation which could be used to transfer water parameter data from the present invention to a receiving apparatus. Other kinds of proprietary protocols to be used with the present invention are possible as well. For example, there is the ISM (industrial, scientific and medical) bands. The ISM bands are defined by the ITU-R in 5.138, 5.150, and 5.280 of the Radio Regulations. Individual countries' use of the bands designated in these sections may differ due to variations in national radio regulations. Because communication devices using the ISM bands must tolerate any interference from ISM equipment, these bands are typically given over to uses intended for unlicensed operation, since unlicensed operation typically needs to be tolerant of interference from other devices anyway. In the United States of America, ISM uses of the ISM bands are governed by Part 18 of the FCC rules, while Part 15 Subpart B contains the rules for unlicensed communication devices, even those that use the ISM frequencies. Part 18 ISM rules prohibit using ISM for communications.

The ISM bands defined by the ITU-R are:

Frequency range [Hz]	Center frequency [Hz]
6.765-6.795 MHz	6.780 MHz
13.553-13.567 MHz	13.560 MHz
26.957-27.283 MHz	27.120 MHz
40.66-40.70 MHz	40.68 MHz
433.05-434.79 MHz	433.92 MHz
902-928 MHz	915 MHz
2.400-2.500 GHz	2.450 GHz
5.725-5.875 GHz	5.800 GHz
24-24.25 GHz	24.125 GHz
61-61.5 GHz	61.25 GHz
122-123 GHz	122.5 GHz
244-246 GHz	245 GHz

While currently the 430 MHz and 9040 MHz frequencies are commonly used in the US, it is anticipated by the Applicants that the other frequencies could be used for water parameter transfers.

Another protocol known as CAN or CAN-bus (ISO 11898-1) that was originally designed for automotive applications, but now moving into industrial applications is another type of network that could be used to transfer water parameter data. Devices that are connected by a CAN network are typically sensors, actuators and control devices. A CAN message never reaches these devices directly, but instead a host-processor and a CAN Controller is needed between these devices and the bus.

It is anticipated by the Applicant that the present invention water use parameter display and monitoring device utilizing the said wireless communication with the one or more remote display and/or recorder apparatus can automatically convert back and forth from radio frequency format, ZigBee or Bluetooth format to a cellular format technology to accommodate different range requirements.

Furthermore, the present invention can communicate utilizing optical technology and other wireless networks such a cell phone technology or private networks.

The transfer of data or information through wired or wireless technology can be initiated using a "wake up" button or signal from the first or second remote display/recorder.

Several different data formats that may be used to exchange data, including but not limited to: binary, XML, XHTML and XHTML Basic, XHTML Basic as an Info-set in another form besides tagged text, Binary encoded equivalents of XML Info-sets including Wireless Binary XML ("WBXML"), ASN.1 encoded XML, SVG, Direct Internet Message Encapsulation ("DIME"), CSV, XML RPC, SOAP (with signature at SOAP level and/or enclosed content level), SOAP (using WS-SECURITY with signature at SOAP level and/or enclosed content level), application specific content like spreadsheet data, an HTTP response to an unsolicited HTTP request, a response to an unsolicited message, HHF, PQDIF, MODBUS, ION®, or other SCADA protocol where a response can be packaged up and embedded in another protocol or format. These formats are frequently sent as MIME or UUENCODE attachments and are considered part of the protocol stack.

The water use and water energy use monitoring activities will require security due to economic impact or violation of municipal or governmental law and ordinances or fraudulent

activities. SPOT is a technology that uses the FM band and is coupled with a new digital radio infrastructure.

There are various security techniques, including encryption, authentication, integrity and non-repudiation that provide secure communications.

With Public Key Encryption, each user has a pair of keys, a public encryption key, and a private decryption key. A second user can send the first user a protected message by encrypting the message using the first user's public encryption key. The first user then decrypts the message using their private decryption key. The two keys are different, and it is not possible to calculate the private key from the public key. In most applications, the message is encrypted with a randomly generated session key, the random key is encrypted with the public key and the encrypted message and encrypted key are sent to the recipient. The recipient uses their private key to decrypt the session key, and the newly decrypted session key to decrypt the message.

Digital signatures are provided by key pairs as well, and provide authentication, integrity and non-repudiation. In this case a sender signs a one-way hash of a message before sending it, and the recipient uses the sender's public key to decrypt the message and verify the signature. When signing large documents, it is known to take a one-way hash function of the plain text of the document and then sign the hash. This eliminates the need to sign the entire document. In some cases, the digital signature is generated by encrypting the hash with the private key such that it can be decrypted using the signers public key. These public/private key pairs and associated certificate key pairs may be computed using hard to reverse functions including prime number and elliptic curve techniques.

One-way Hash Functions are small pieces of data that identify larger pieces of data and provide authentication and integrity. Ideal hash functions cannot be reversed engineered by analyzing hashed values, hence the 'one-way' moniker. An example of a one-way hash function is the Secure Hash Algorithm. X.509 and PGP each define standards for digital certificate and public key formats.

Various encryption algorithms such as RSA, Advanced Encryption Standard ("AES"), DES and Triple DES exist. RSA is a commonly used encryption and authentication system for Internet communications.

Secure Sockets Layer ("SSL") creates a secure connection between two communicating applications. For the purposes of the disclosed embodiments, SSL and Transport Layer Security ("TLS") are equivalent. These protocols are employed by web browsers and web servers in conjunction with HTTP to perform cryptographically secure web transactions. A web resource retrievable with HTTP over TLS is usually represented by the protocol identifier "https" in the URL. TLS can and is used by a variety of Application protocols.

Secure HTTP (S-HTTP or HTTPS) provides independently applicable security services for transaction confidentiality, authenticity and integrity of origin.

S/MIME and Pretty Good Privacy ("PGP") provide encryption and authentication for email and other messages, allowing users to encrypt a message to anyone who has a public key. This technology allows a message to be signed with a digital signature using a private key, preventing individuals from reading messages not addressed to them.

Microsoft Passport is an online service that allows a user to employ their email address and a single password to create a unique identity.

Internet Protocol Security ("IPSec") secures IP traffic across the Internet, and is particularly useful for implementing VPNs. Point-to-Point Tunneling Protocol ("PPTP") is a protocol that allows entities to extend their local network through private "tunnels" over the Internet. This kind of connection is known as a VPN. Layer Two Tunneling Protocol ("L2TP) is an extension of the PPTP protocol.

A Media Access Control Address ("MAC Address") is a number that is appended to a digital message and provides authentication and integrity for the message.

The XML Signature syntax associates a cryptographic signature value with Web resources using XML markup. XML signature also provides for the signing of XML data, whether that data is a fragment of the document which also holds the signature itself or a separate document, and whether the document is logically the same but physically different. This is important because the logically same XML fragment can be embodied differently. Different embodiments of logically equivalent XML fragments can be authenticated by converting to a common embodiment of the fragment before performing cryptographic functions. XML Encryption provides a process for encrypting/decrypting digital content, including XML documents and portions thereof, and an XML syntax used to represent the encrypted content and information that enables an intended recipient to decrypt it.

Before the water use and water energy use monitoring apparatus base station **10**, **126** and remote displays and/or recorders **52**, **54** (and **110** as shown in detail in FIG. **5**) or cell phone, smart phone, or other similar apparatus (see FIG. **9**) should communicate securely with one another and therefore they need to be provided with identities. The identity must not be easy to assume either intentionally or accidentally.

Identities are particularly relevant in multi-site scenarios, where the water use and water energy use monitoring apparatus base stations **10**, **126** are aggregated across a wide geographic area containing multiple sites, serviced by multiple utilities, each site operating on one or more municipal agencies. Each water use and water energy use monitoring apparatus base station **10**, **126** needs to identify itself when queried by a civil, commercial, municipal or governmental operator or agency.

In one example, each water use and water energy use monitoring apparatus **10**, **126** will be identified and verified to see if its identification is already in the central storage. This identity can be implemented using various values, including MAC address, Universal Unique Identifier ("UUID"), TCP/IP address, DNS name, email address, serial number, an unique string of characters issued by a municipal or governmental agency.

It is important that within a given geographic area, no two water use and water energy use monitoring apparatus base station **10**, **126** will have the same identity. It is therefore preferred that the entity, municipality or authority name become a portion of the identity. The fabrication process could include inserting a unique identity in the water use and water energy use monitoring apparatus base station **10**, **126** at manufacturing or repair time.

To protect its identity, it should be stored in a location that cannot be easily accessed or replaced either physically or electronically.

PKI certificate based authentication schemes are utilized for machine-to-machine authentication. The water use and water energy use monitoring apparatus base station **10**, **126** is issued one or more PKI certificates, associated identities and identity-related secrets, such as private keys, during manufacturing. Alternately, an identity and certificate are assigned by an authority unrelated to the device manufac-

turer and transferred to water use and water energy use monitoring apparatus 10, 126 in a manner that keeps all secrets private.

A user registry maintains a database of device identities, associated with installed and operating water use and water energy use monitoring apparatus base station 10, 126. The registry must be updated whenever a water use and water energy use monitoring apparatus base station 10, 126 is brought into or removed from service. The registry may be implemented as a distributed registry with a host name encoded within the Metering Point corresponding to a registry for that particular host. Alternatively, the registry can be implemented as a single large database. The registry can be implemented as a relational database, XML files, Comma Separated Value ("CSV") files, or Resource Description Files ("RDF"), or any mechanism that allows associated lookup when combined with the appropriate software. The registry enforces uniqueness of metering points, thereby preventing two devices from having the same identification address at the same instant.

Encryption, authentication, integrity and non-repudiation may be important characteristics when the water and energy use monitoring apparatus base station 10, 126 is sharing data or information with the remote displays. When a water use and water energy use monitoring apparatus 10, 126 receives or uploads data and information such as a control command signal to send or transmit data and information it is critical that the device can authenticate the sender and be sure of the integrity of the data and information. Encryption provides privacy by preventing anyone but the intended recipient of a message from reading it. Encryption can be provided point-to-point, or end-to-end, depending on the nature of the channel and the data. Only a portion of the data may be encrypted. EM Components can encrypt messages using encryption schemes such as PGP, S/MIME, XML Encryption, or SSL. Signing data provides assurance that the data comes from the desired source, and that it has not been tampered with. Signing helps prevent so-called "man in the middle" attacks where someone with legitimate or illegitimate access to data intercepts the data and tampers with it or forges data. This can occur with all aspects of communication, including installing certificates, and exchanging frameworks and all types of EM data.

Non-repudiation prevents the sender from denying that they sent a message. Non-repudiation can be provided by signing, electronic witnessing and technologies that assert a document was read before it was signed. Similar techniques exist for ensuring non-repudiability of contracts. Here, the water use and water energy use monitoring apparatus 10, 126 include sign data, data packets or messages using PGP, S/MIME, XML Signature or TLS/SSL to provide for non-repudiation of those messages or data.

The water use and water energy use monitoring apparatus base station 10, 126 will communicate with the residential or commercial remote display and/or recorder apparatuses 50, 56 (and 110 as shown in detail in FIG. 5) and the remote station at a specifically determined timing frequency. The remote and/or recorder apparatuses 50, 56 can be a cell phone, smart phone or other similar apparatus (see FIG. 9). This update frequency can be programmed into the present invention for various time periods, e.g. once per minute, twice per hour, once per minute, once per hour, once per day, once per week, or once per month/year. In the optional second wireless communication means 54 with outside civil, commercial, governmental or municipal agencies, data and information can be sent only occasionally or upon demand. Also the data or information can be processed-by an automated system and reports are only created every day, or week, or month, there is some leeway in when the data must be sent. The water use and water energy use monitoring apparatus base station 10, 126 can be programmed to communicate at other time frequencies, such as every 5 seconds or every minute, for various purposes, for example, to identify leaking conditions. In this case, encryption and signing calculations can be executed only when there is free processing time. This scheme performs well on water use and water energy use monitoring apparatus base station 10, 126 where important real-time calculations can take up significant available calculation time for small periods, but over time periods of a few hours there is processing time to spare.

In an another embodiment, encrypted data is streamed across the Internet or cell tower technology as it is generated using the aforementioned techniques. This has the advantage that water use and water energy use monitoring apparatus 10, 126 does not need to store encrypted data.

In an another embodiment, water use and water energy use monitoring apparatus base station 10, 126 contains a removable or a non-removable storage device that can contain water and energy parameter data. This removable storage device may be removed from time to time to upgrade configuration data, or to download stored data to a remote computer or apparatus. The water use and water energy use monitoring apparatus base station 10, 126 may be fitted with a physical lock that prevents unauthorized individuals from taking the removable storage device.

A resident or commercial consumer of data and information may wish to verify that received data represents what the data the civil, commercial, government or municipal provider claims it represents. It is difficult for a user to confirm the calculation techniques, source registers and source modules used to arrive at a value, so some techniques are needed to aid in this endeavor.

Software may be designed to check for valid signatures before an upload is attempted, and only allow certain users to upload unverified firmware. The firmware itself may verify signatures to ensure firmware has not been tampered with and is from an authorized source, and that the entity attempting the upgrade is authorized to perform an upgrade. Third parties may upload their own firmware written in their language of choice, such as Java, Prolog, Haskell, binary executable code, C#, ECMA Common Language Runtime ("ECMA CLR"), or ION® Object Configurations. Depending on the platform, source code or some repurposed version of the source code (i.e. ECMA CLR or target processor machine code) is digitally signed by the party and uploaded. Such code would be allowed to perform only specific actions based on trust level of the signer. For example, unsigned code or code signed by a non-trusted entity will not be allowed to read the second wireless communication mean 54 or the third wireless communication means 46. In additional, the water and energy monitoring base station 10, 126 or the first remote display and/or recording means 50 could has a microprocessor that includes a data memory bank for are calling the water and/or energy use parameter data that can be compared with the data that is uploaded by the government or municipal second remote display/recording means 56 or the data the is uploaded by the wireless cellular format communication means 46 remote states.

In operation, before water use and water energy use monitoring apparatus 10, 126 can transmit data or information to the second optional remote, it must verify that the second display remote is authorized to communicate with the present invention.

In addition, any stored data, including cached data and data stored in a database, is tagged with a digital signature. When the data is retrieved, the digital signature can be used to verify that the data has not been tampered with over time.

As shown in FIG. 1 but applicable to FIG. 6, is a first wired or wireless communication means **52** from the water use and water energy use monitoring apparatus base station **126** for communicating water use information or data to a conveniently located first remote display and/or recorder apparatus **50** (defined in more detail in FIG. 5) located in a convenient location for the commercial operator or occupier or residential individual to observe daily, weekly, monthly or annual water use. The first remote display and/or recorded apparatus **50** can be a typical cell phone, smart phone, or similar apparatus (see FIG. 9) that is using wireless, Bluetooth technology or other wireless technology. The first wireless communication means **52** preferably utilizes some confidential technology such as encryption, authentic, integrity and non-repudiate techniques to provide a secure transfer of the water use from the monitoring base station apparatus **126** to the first remote display and/or recording apparatus **50**. The first wired or wireless communication means **52** can send data on various frequencies, e.g. once per minute, once per hour, once per day, once per week, one per month/year or can send information upon sensing an initiation to the first remote and/or recording apparatus **50**. Furthermore, the first wired or wireless communication means **52** can send data or information upon the sending of a request signal. The request signal can be generated by, for example, the pushing of a requesting button located on the first remote display and/or recording apparatus **50** that transmits a request for water use data to the water and water energy monitoring apparatus base station **10**, **126**. The use of the request signal can minimize the use of wireless signals within the house or commercial building, conserving energy, minimizing the interference with other wireless devices, and reduce the exposure of wireless energy to individuals. Furthermore, the first wireless communication means **52** can consist of two-way transmission, commonly known as transceiver technology, such that the monitoring display apparatus base station **126** can transmit and receive electronic signals from the first display and/or recording apparatus **50** and similarly, and the first display and/or recording apparatus **50** can transmit and receive electronic signals from the monitoring display apparatus base station **126**. Hence, the first wired or wireless communication means **52** can be either one-way transmission, or half duplex and/or full duplex two-way transmission.

As shown in FIG. 1 but applicable to FIG. 6, the second optional wireless communication means **54** is preferred to transmit, upload or download water parameter data or information via a secure wireless communication network providing information to a property owner, governmental, civil or municipal employee or individual **60** using a second remote display and/or recorder apparatus **56** for governmental, civil, commercial or municipal operators or agencies purposes. It is anticipated that the second wireless communication means **54** can also be received by a moving vehicle or can communicate with cellular format technology utilizing cell towers **44** using another third wireless communication **46**. The second optional wireless communication means **54** preferably utilizes some confidential technology such as encryption, authentic, integrity and non-repudiate techniques to provide a secure transfer of the water use from the monitoring base station apparatus **126** to a second display and/or recorder **56**. The second display and/or recorded can be a typical cell phone, smart phone, or similar apparatus (see FIG. 9) that is using wireless, Bluetooth technology or other wireless technology. Also, the second wireless communication means **54** should include specific identification information e.g. house or commercial building address, IP address or a similar unique technology. The second optional wireless **56** communication means can send data on various frequencies, e.g. once per minute, once per hour, once per day, or can send information upon sensing an initiation to the second remote and/or recorder **56**. Furthermore, the second optional wireless communication means **56** can send data or information upon the sending of a request signal. The request signal can be generated by, for example, the pushing of a requesting button located on the second remote display and/or recorder **56** that transmits a request for water use data to the water and energy monitoring apparatus base station **126**. The use of the request signal can minimize the use of wireless signals within the house or commercial building, conserving energy, minimizing the interference with other wireless devices, and reduce the exposure of wireless energy to individuals. Furthermore, the second wireless communication means **54** can consist of two-way transmission, commonly known as transceiver technology, such that the monitoring display apparatus base station **126** can transmit and receive electronic signals from the second display and/or recording apparatus **56** and similarly, and the second display and/or recording apparatus **56** can transmit and receive electronic signals from the monitoring display apparatus base station **126**. Hence, the second optional wireless communication means **46** can be either one-way transmission, or half duplex and/or full duplex two-way transmission.

As shown in FIG. 1 but applicable to FIGS. 5, 6 and 9, is the third optional wireless communication means **46** is designed to communicate data under a cellular format technology with offsite central monitoring computer or cell, mobile or other telephone lines via satellite, microwave technology, the internet, cell tower, telephone lines, and the like. It is anticipated that the third wireless communication means **46** can transmit information to a programmed cell or phone number for communicating water parameter data or alarm situations to the property owner or a municipal/governmental agency (such as announcing a water leak situation). The information can be send to a typical cell phone, smart phone, or similar apparatus (see FIG. 9). Also, the third wireless communication means **46** should include specific identification information e.g. house or commercial building address, IP address or similar unique technology. The third wireless communication means **46** can send data on various frequencies, e.g. once per minute, once per hour, once per day, once per week, once per month/year or can send information upon sensing the initiation (alarm situation) to the programmed cell or phone number. The request signal can be generated by, for example, a request signal transmitted by a remote station (not shown). The use of the request signal can minimize the use of wireless signals within the house or commercial building, conserving energy, minimizing the interference with other wireless devices, and reduce the exposure of wireless energy to individuals. Furthermore, the third wireless communication means **46** can consist of two-way transmission, commonly known as transceiver technology, such that the monitoring display apparatus base station **126** can transmit and receive electronic signals from the remote station and similarly, the remote station can transmit and receive electronic signals front the water use and water energy use monitoring display apparatus base station **126**. The third wireless means **46** can also be designed for communicating to an offsite central monitoring computer or cell, mobile or other telephone lines via satel-

lite, microwave technology, the internet, cell tower, telephone lines, and the like. The third communication means **46** can also comprise a RF mesh-enabled device (meters, relays) is connected to several other mesh-enabled devices, which function as signal repeaters, relaying the data to an access point. The access point device aggregates, encrypts, and sends the data back to a municipal or government agency over a secure commercial third-party network. The resulting RF mesh network can span large distances and reliably transmit data over rough or difficult terrain. If a meter or other transmitter drops out of the network, its neighbors find another route. The mesh continually optimizes routing to ensure information is passed from its source to its destination as quickly and efficiently as possible. The third optional wireless communication can be either one-way transmission, or half duplex and/or full duplex two-way transmission.

Referring now to the drawings and particularly to FIG. **2** is a perspective view of the first embodiment comprising a water/energy use monitoring display apparatus **10** attached to the cold and hot input water supply piping **14** and the cold and hot output water supply piping. The first embodiment of the show display apparatus **10** is designed to become attached to water supply piping in easily installation and aesthetically pleasing format. In the first embodiment, the water use and water energy use display and monitoring apparatus **10** should be installed near the hot and cold or ambient water sources before any distribution lines such that the total volume or quantity of hot and cold or ambient water can be monitored and recorded. In the second embodiment **126** where only the water use is monitored, the present invention water parameter use display and monitoring device can be installed near the cold or ambient water source or supply line before the hot water generation device and before any distribution lines (e.g. at the pressure regulator) such that the total volume or quantity of cold or ambient water can be monitored and recorded. It is anticipated by the Applicant that the present invention water parameter use display and monitoring device **126** can be incorporated into or serve as the pressure regulator (pressure reduction valve) or primary water meter at residential or commercial facilities. The components of the first embodiment of the present invention include a plurality of water pipe joint unions or sections **30**, **32**, **34** and **36**, a housing section **18** containing the electrical circuitry and microprocessor, a power source with a water proof removable cover, and first **12**, second **14** and third **16** water use and water parameter display mechanisms.

The plurality of water pipe unions or joints **30**, **32**, **34** and **36** can be fabricated from typical metallic piping materials such as brass, brass alloys, steel, galvanized steel, copper, copper allows or any combination thereof. The water pipe joint can be fabricated from a number of polymeric materials, such as polyvinyl chloride (PVC), polyethylene, polybutylene, acryaontirile-butadiene-styrene (ABS), rubber modified styrene, polypropylene, polyacetal, polyethylene, or nylon. The base material can be painted white or colored finishes or coated with various brass, silver and gold type materials to accommodate the match with various presently marketed finishes. As shown in FIG. **2**, the water union or joints **30**, **32**, **34**, and **36** generally have a female thread (not shown) within the input end for engaging the male treads of a typical water supply lines **20** and **22** and water delivery lines **24** and **26**. For certain applications, the male/female thread locations can be changed to accommodate certain attachment forms or specifications. In addition, other attachment means, such as adhesive, snap fit joint, compression fitting, flare fitting or other technologies can be employed.

The material for fabricating the water pipe union or joint **30**, **32**, **34** and **36** is not particularly important except that the union or joint has to engage the water supply and delivery lines with a relatively water tight seal, and that preferably there should be a sealing means that functions 1) to secure in place, any parameter sensors that are projecting into the water stream and 2) to provide a water-tight seal that can prevent any water from penetrating past the seal and 3) include structural integrity to withstand continuous water pressure and other forces Various washer designs fabricated from compounds of rubber, urethane, elastomeric or thermosetting polymeric compounds have been disclosed and are in present in similar uses. Seal and sealing technology is well known in the art. The joint between the water pipe union and the water supply and delivery lines could be screw and thread technology, snap fit, compression fitting, flare fitting, or use adhesive technology. For example, in the case of fabricating with a metallic component, a solder, brazed, or sweat joint could be used. For example, in the case of polymeric, the extending or articulating could be an extension of the display apparatus manufactured by molding, heat bonding, or adhesive technology. The joint may be designed to be permanent or removable.

Further referring to FIG. **2**, the present invention base station apparatus **10** includes a housing **18**, a computerized circuit board (depicted in FIG. **3**), the display means housing having a optional door for replacing or regenerating the power source or removable data chip and a plurality of buttons or activators **19**, **21**, and **23**, or software buttons (e.g. touch screen technology) **140**, **142**, and **144**, that allow for certain modification of the software instructions (change units, change language, change from metric to US standard, set alarms, calibrate sensors, or establish communication with wired or wireless sensors). While FIG. **2** shows three hard buttons **19**, **21** and **23** and three software button activators **140**, **142** and **144**, it is anticipated by the Applicant that a different series of hard or software buttons can be used, and/or a different series of software button sequencing can be utilized. Furthermore, other hard button technology can be used, such as a rotary switches or multiple membrane switch technology. The housing **18** can be fabricated from a metallic material such as brass, brass alloys, steel, galvanized steel, copper, copper allows or any combination thereof. The display means housing can be fabricated from a number of polymeric materials, such as polyvinyl chloride (PVC), polyethylene, polybutylene, acryaontirile-butadiene-styrene (ABS), rubber modified styrene, polypropylene, polyacetal, polyethylene, or nylon. The base material can be painted white or colored finishes or coated with various brass, silver and gold type materials to accommodate the the match with various presently marketed finishes. The material for fabricating the housing **18** is not particularly important except and the size of the display means will generally determine the size of the housing but it does not have to be substantially rectangular as shown, any number of geometric configurations could be used in the present invention.

The plurality of display means **12**, **14**, and **16** and as presented in FIG. **2** utilizes one or more illuminating technologies, such as LCD, LED, gas plasma, fluorescence, incandescent, halogen, halide, or other lighting technologies but should be able to provide sufficient lighting for observing the data and information in dark conditions. In addition, the display means and display means housing should be able to sustain capability in moist wet conditions. The present invention can include one or more than one display means

to show various water use and water energy use parameters. Provided only as an example, display means 12 can display different levels of water use with a color hue or format providing a visual cue. For example, a water supply municipal can have data to be downloaded to the base station 10, 126 so that a green background or parameter digits for a 1st hundred cubic feet (e.g. a first 14 HCF) level, yellow background or parameter digits for a 2nd hundred cubic feet (e.g. second 14 HCF) level, and red background or parameter digits for a 3rd hundred cubic feet (e.g. a third 28 HCF) level can be displayed. In addition, costs for the hundred cubic feet water can be downloaded and displayed. For example, the other embodiment with only the flow and water use display can be manufactured to reduce overall costs. The optional displays 12, 14 and 16 can have touch screen capability. Furthermore, the orientation of the water use and water energy use parameters can be presented in various formats. For example, the flow parameter can be on top 12 with the date parameter on the bottom 16 and with the energy parameter sandwiched between 14. The optional displays 12, 14, and 16 can have a background light or parameter alpha-numeric digits that is used for various purposes, for example, for providing better lighting conditions or changing color e.g. from green to yellow and to red, to display an alarming condition (e.g. water use over time has exceed a certain level). It is also anticipated that the displays 12, 14 and 16, can have various colors displayed at once (e.g. blue and green characters with a white or yellow backlight. Displaying of all water and water energy parameters can utilize a gang multiple LCD, LED, gas plasma, fluorescence, incandescent, halogen, halide, or other lighting technologies separate displays, custom displays, graphic displays or a single line display which sufficient digits that sequences the presentation of the water parameters and water energy parameters one at a time with a specific delay and sequencing. An example of a LCD unit that can be used with the present invention is the color graphic 128×128 LCD-00569 marketed by Sparkfun Electronics in Boulder, Colo. Digitikey, Mouser and other electronic supply warehouses have many other variants and other LCD, LED, gas plasma, fluorescence, incandescent, halogen, halide, or other lighting technologies that can be utilized with the present invention.

The optional display means 12, 14, and 16 can be programmed to display one or more parameters in a visual means that can be either an analog, character or digital display, or combination of display means. Information obtained from the appropriate sensor monitoring or measuring the water parameters such as temperature, date/time, flow rate or water quality parameters can be displayed in an appropriate format on the display means. The optional displays 12, 14 and 16 can have touch screen capability. For example, when a sensor is monitoring or measuring the rate of water flowing from a water source or the display means could show any flow between 1.0 gal/min (3.8 liters/min) to many thousands of gals/day. For example, when a sensor is monitoring the temperature of hot and cold (ambient) water flowing through the housing, the display means could show any energy ratio calculation that takes into effect the overall temperature and total volume of heated water vs. the total volume of cold or ambient water. It is anticipated by the Applicant that many different water energy calculations might be utilized by the present invention. Furthermore, the display can be programmed to display calendar information, such as the date and current time (12 hr. or 24 hr. format). The optional displays 12, 14, and 16 can have a background light or parameter alpha-numeric digits that is used for various purposes, for example, for providing better lighting conditions or changing color e.g. from green to yellow and to red, to display an alarming condition (e.g. water use over time has exceed a certain level). It is also anticipated that the optional displays 12, 14 and 16, can have various colors displayed at once (e.g. blue and green characters with a white or yellow backlight.

It is anticipated by the Applicant the present invention can be fabricated and marketed with one, two or more display means. For example, a lower cost display assembly can be fabricated and sold that only has a temperature sensor and temperature display means. A more expensive display assembly can be fabricated and sold that has temperature, flow, timing and other sensors with various programmed methods and a shut off mechanism.

Also shown in FIG. 2, one or more ergonomically 19, 21, and/or 23 placed buttons or activators can be incorporated into the display means housing to allow the modification of certain parameter units (e.g. metric to US), set alarm conditions (e.g. flow/volume rate-set points), or to program certain settings, e.g. over water use alarm, monitor continuous leakage (e.g. valve not completely shut off, broken pipe), calibrate sensors, or establish communication with wired or wireless sensors. The buttons will electrically communicate with the electronic circuit board contained with the housing 18 and respond to programmed instructions integrated within the CPU or microprocessor and associated circuitry of the electronic circuit board. The buttons or activators 19, 21 and/or 23 should be mounted with the display means housing 18 with the capability to protect the buttons and electronic circuitry with the housing for exposure to moist and wet conditions. Software buttons 140, 142, and 144 (e.g. touch screen technology) can replace or be used in conjunction with the button or activators 19, 21, and 23.

A visual alarm or signal can be incorporated into the present invention whereby a preset alarm or programmed alarm, changes the one or more of the screen displays, for example, blinking a parameter or backlight, or changing the color of a parameter or backlight (e.g. green to yellow to red). For example, one or more displays can exhibit a first background or text color (e.g. green) when a first volume range of water use has been monitored. After a second volume range of water use has been monitored, the one or more displays can exhibit a second background or text color (e.g. yellow). And when a third volume range of water use has been monitored, the one or more displays can exhibit a third background or text color (e.g. red) when a third volume range of water use has been monitored.

A preset alarm might include visual reference, for example, an in-operative condition, broken sensor, low power source, leaking condition, optional sensor warning (e.g. chlorine level, TDA, biological, hardness or pH levels high), and some other default limits. Programmed visual alarms would allow for individual selection (e.g. volume over set point, flow rate set point, total volume exceeded set points) which might be restricted or not by the default settings.

In addition, an auditory alarm (or combined visual/auditory) can be incorporated into the present invention whereby a preset alarm or programmed alarm, changes the screen display (flashing), for example, using sound or pulsing a specific noise, or changing the color of a parameter. For example, the temperature display can change from green to yellow to red when a water use levels are crossed with an auditory signal. A preset alarm might include visual reference, for example, an in-operative condition, broken sensor, low power source, leaking condition, optional sensor warn-

ing (e.g. chlorine level, TDA, biological, hardness or pH levels high), and some other default limits. Programmed auditory or visual alarms would allow for individual selection (e.g. temperature over set point, time past set point, flow rate set points) which might be restricted or not by the default settings.

In addition, the water use monitoring display apparatus **10**, **126** can include water shut off or variable water flow means to turn completely or partially turn off the water supply if an alarm condition or setting point is exceeded and has been activated. The variable water flow means can set the water flow to be anywhere between 1% and 99% of the total water supply flow. The water shut off means or variable water flow means is electrically connected to the CPU or microprocessor **84** and the power means thereby controlling the application of electrical power to activate or de-activate the water shut off means or variable water flow means. The water shut off means or variable water flow means can comprise, for example, a typical ball valve or solenoid shut off valve incorporate into the connection union such that water from the source is closed such that no water exits the shower or bath water head. The water shut off means or variable water flow means can be activated if an alarm state has been achieved, e.g. 200 gals/day of water is exceeded or the total of 15 gallons of water has flowed since the water source was closed. The alarm or settings can be a default setting installed by the manufacturer or programmed by the user. The water shut off means or variable water flow means can be activated by software instructions, or initiated by a command communicated over the optional second **54** and third **46** wireless means. As an example, many irrigation manufactures (Orbit, Hunter irrigation products) incorporate battery control valves and there are numerous other flow valves using standard electrical energy are available, e.g. ball valves, gate valves, butterfly valves.

Now referring to FIG. **3**, shown is a is a timing clock integrated circuit **88** with data transfer means **89** for communicating with the CPU or microprocessor **84** and having a power line **85** and ground line **86**, a temperature sensor or temperature integrated circuit **93** with a data transfer means **92** for communicating with the CPU or microprocessor **84** and having a power line **96** and ground **97**, and the flow sensor (e.g. pressure, ultrasonic, turbine flow) or flow sensor integrated circuit **95** with a data transfer means **94** for communicating with the CPU or microprocessor **84** with a power line **98** and ground line **99**. The power line **98** can utilize battery technology or other DC power sources, or can be AC powered using standard 120 or 220/240 volt supply lines, or 24 volt low AC power that is commonly used for sprinkler systems. It is anticipated that a water flow generation apparatus that can be utilized with rechargeable batteries for powering the water and water energy monitoring base unit **10**, **126**. The integrated circuits for the timing clock **88**, temperature sensor **93** and flow sensor **95** can include circuitry to convert analog data to a digital format. Also shown is a first wire or wireless electronic communication means **100** with a data transfer means **104**, and a second wire or wireless electronic communication means **101** with a data transfer means **102**, where both data transfer means **102** and **104** communicates with the CPU **84**.

The microprocessor **84** that processes the information supplied by the various sensors described herein (FIG. **4**) uses internal instructions to control the information projected on the display **80** and for processing alarm states. The microprocessor can include an EEPROM or any type of memory section that allows for specific programming to be incorporated as processing instructions. Furthermore, the microprocessor **84** may have the capability to convert analog signals into digital information for decoding and processing. An example of a microprocessor **84** that could be used is the PIC16F876 28-pin 8-Bin CMOS FLASH micro-controllers manufactured by Microchip Technology, Inc. This particular microprocessor has a 128K EEPROM Data memory bank for flash memory of specific instructions and utilizes a 35-word instruction set. It also has five 10-bit Analog-to-Digital Inputs that can provide the means for converting the information obtained from the various sensors described herein (FIG. **4**) from its analog format into a digitized form for processing by the instruction sets of the CPU or microprocessor **84**. Another example of a microprocessor **84** that could be used for the CPU or microprocessor is the MSP430 family of processors from Texas Instruments in Dallas, Tex. There are hundreds of variants but for an example, the MSP430F436IPN (80 pin package) or MSP430F436IPZ (100 pin package) could be utilized in the present invention. It is anticipated by the Applicant that more powerful microprocessors with more memory capacity may be utilized to accommodate the more complex audio or verbal communications means. There are many other variants or other microprocessors, whether commercially marketed or privately fabricated, that can be used with the present invention.

In addition, a means to record and digitally story the water parameters or data can be incorporated into the present invention. An integrated memory circuit can be incorporated into the CPU or microprocessor **84**, or can be a separate memory circuit, and can include associated circuitry with a means to transfer the recorded data to a removable media, such as a flash mount on an electronic circuit board to control the display means and communicate with the sensors. Various data access ports, such as serial, parallel, or USP, internet, can be used to transfer the stored data to another device, such as a computer. The CPU or microprocessor **84** and associated circuitry mounted on the electronic circuit board can also have the capability to be programmed for controlling certain display means (e.g. U.S. or metric units), programming alarm or setting states (e.g. flash all display means different colors e.g. red when the total volume has exceeded a certain volume, for example, 200 gallons/day).

Also shown in FIG. **3**, is the timing circuit **88** functioning to communicate with the CPU or microprocessor **84** to display such information such as the time of day and current date and/or a time stamp for the duration that the water supply has turned been on and off. For monitoring the time stamp parameters of the water flowing through the present invention, the use of various trip switches or water sensors as depicted in FIG. **4** are positioned in close proximity to the flowing water to be monitored. Various mechanical, magnetic or software switches can be utilized to communicate a signal to the CPU or microprocessor **84** that water supply has been initiated and then the software instructions and CPU or microprocessor can display the cumulative time that the water supply is flowing through the present invention. The mechanical, magnetic or software switch will have the capability to also communicate a signal to the CPU or microprocessor **84** that the water supply has been shut off such that the software instructions and CPU or microprocessor can calculate various parameters, such as, but not limited to, the duration of water supply, total number of gallons or liters of water used and flow rates.

Technologies that can be use as the timing circuit **88** include electrical resistance sensors, ohm meter, multi-meter electrical current sensors: galvanometer, ammeter, electrical

voltage sensors: leaf electroscope, voltmeter electrical power sensors, watt-hour meters magnetism sensors, magnetic compass, fluxgate compass, magnetometer, Hall effect device. In addition, various chemical technologies, such as oxygen sensors, ion-selective electrodes, and redox electrodes might be used. Furthermore, optical radiation technology can be used as the timing sensor, such as light sensors, on photo-detectors including semi-conduction devices such as photocells, photodiodes, phototransistors, CCDs, and image sensors; vacuum tube devices like photo-electric tubes, photomultiplier tubes, and mechanical instruments such as the Nichols radiometer, infra-red sensors, especially used as occupancy sensors for lighting and environmental controls, interferometry-interference fringes between transmitted and reflected light-waves produced by a coherent source such as a laser are counted and the distance is calculated. In addition, fiber optic sensors are capable of extremely high precision.

Because the present invention water use and water energy monitoring apparatus can be used in situations where the source of water comes for a well or non-commercial operation, and furthermore, where the commercial operations water treatments plants are under pressure to provide more water supplies or where problems, breakdowns or accidental situations can cause contamination of the water source, the present invention can be fitted with, display parameters of, and provide warning for, numerous mineral, elements and biological contaminates. As illustrated in FIG. **4** is a cross-section showing the one or more sensors **70**, **72**, **74**, **76**, **78**, **80**, **140** and/or **142** located in close proximity to water supply line **20**, **22** and/or a water delivery supply line **24**, **26** and their relative position of the sensors in the supply line lumen **38** and the connecting wires **71**, **73**, **75**, **77**, **79**, **81**, **141** and **143** for the display means. For exemplary purposes, sensor **70** could be a timing sensor e.g. to monitor when water is flowing, sensor **72** can be a temperature sensor, sensor **74** can be a flow sensor, **76** can be a halogen (e.g. chloride or fluoride) sensor, **78** can be a total dissolved solids sensor, **80** can be a biological or fecal sensor, and **140** can be a water hardness sensor and **142** can be a specific iron or other mineral sensor.

In general, a sensor is a type of transducer. A direct type indicating sensors, for example, a mercury thermometer, is human readable. However, other sensors must be paired with an indicator or display, for instance, thermocouple sensor. Most sensors are electrical or electronic, although other types exist.

Technological progress allows for more and more to be manufactured on the microscopic scale as micro-sensors using MEMS technology. In most cases a micro-sensor reaches a significantly higher speed and sensitivity compared with macroscopic approaches.

There are many types of sensors that can be used with the present invention. Since a significant small change involves an exchange of energy, sensors can be classified according to the type of energy transfer that they detect. For measuring or monitoring the temperature of the water flowing from the shower or bath head, the use of various thermocouples or thermistor sensors **70** as depicted in FIG. **3** is protruding within the water supply lumen **38** (or in close proximity to the water to be measured) and mounted within the articulating joint mechanism **22**. Wires **71** are shown extending from the sensor **70** to electronically communicate with the CPU or microprocessor **84** and display unit.

In 1821, the German-Estonian physicist Thomas Johann Seebeck discovered that when any conductor (such as a metal) is subjected to a thermal gradient, it will generate a voltage. This is now known as the thermoelectric effect or Seebeck effect. Any attempt to measure this voltage necessarily involves connecting another conductor to the "hot" end. This additional conductor will then also experience the temperature gradient, and develop a voltage of its own which will oppose the original. Fortunately, the magnitude of the effect depends on the metal in use. Using a dissimilar metal to complete the circuit will have a different voltage generated, leaving a small difference voltage available for measurement, which increases with temperature. This difference can typically be between 1 and 70 micro-volts per degree Celsius for the modern range of available in metal combinations. Certain combinations have become popular as industry standards, driven by cost, availability convenience, melting points, chemical properties, stability, and output.

It is important to note that thermocouples measure the temperature difference between two points, not absolute temperature. In traditional applications, one of the junctions, the cold junction, was maintained at a known (reference) temperature, while the other end was attached to a probe.

For example, the cold junction could be at copper traces on the circuit board. Another temperature sensor will measure the temperature at this point, so that the temperature at the probe tip can be calculated. Having available a known temperature cold junction, while useful for laboratory calibrations, is simply not convenient for most directly connected indicating and control instruments. They incorporate into their circuits an artificial cold junction using some other thermally sensitive device (such as a thermistor or diode) to measure the temperature of the input connections at the instrument, with special care being taken to minimize any temperature gradient between terminals. Hence, the voltage from a known cold junction can be simulated, and the appropriate connection applied. This is known as cold junction compensation.

Additionally, cold junction compensation can be performed by software. Device voltages can be translated into temperatures by two methods. Values cast either be found in look-up tables or approximated using polynomial coefficients.

Any extension cable or compensating cable must be selected to match die thermocouple. It generates a voltage proportional to the difference between the hot junction and cold junction, and is connected in the correct polarity so that the additional voltage is added to the thermocouple voltage, compensating for die temperature difference between the hot end cold junctions.

The relationship between the temperature difference and the output voltage of a thermocouple is generally nonlinear and is approximated by a polynomial interpolation.

$$T = \sum_{n=0}^{N} a_n v^n$$

The coefficients a_n are given for n from 0 to between 5 and 9. To achieve accurate measurements lie equation is usually implemented in a digital controller or stored in a lookup table. Some older devices use analog filters.

A variety of thermocouples are available, suitable for different measurements applications (industrial, scientific, food temperature, medical research, etc.). They are usually selected based on the temperature range and sensitivity needed. Thermocouples with low sensitivities (B, R, and S

types) have correspondingly lower resolutions. Other selection criteria include the inertness of the thermocouple material, and whether or not it is magnetic. The thermocouple types are listed below with the positive electrode first, followed by the negative electrode. For example, listed below are a number of thermocouples types.

Type K—Chromel (Nickel-Chromium Alloy)/Alumel (Nickel-Aluminum Alloy). This is the most commonly used general purpose thermocouple. It is inexpensive and, owing to its popularity, available in a wide variety of probes. They are available in the 200° C. to +1200° C. range. Time type K was specified at a time when metallurgy was less advanced than it is today and, consequently, characteristics vary considerably between examples. Another potential problem arises in sonnies situations since one of the constituent materials is magnetic (Nickel). The characteristic of the thermocouple undergoes a step change when a magnetic material readies its Curie point. This occurs for this thermocouple at 354° C. Sensitivity is approximately 41 µV/° C.

Type B—Chromel/Constantan (Copper-Nickel Alloy). Type B has a high output (65 µV/° C.) winch makes it well suited to cryogenic use. Additionally, it is non-magnetic.

Type J—Iron/Constantan. Type J has a limited range (−40 to +750° C.) makes type J generally less popular than type K. The main application is with old equipment that cannot accept modern thermocouples. J types cannot be used above 760° C. as an abrupt magnetic transformation causes permanent de-calibration. The magnetic properties also prevent use in some applications. Type J's have a sensitivity of ~52 µV/° C.

Type N—Nicrosil (Nickel-Chromium-Silicon Alloy)/Nisil (Nickel-Silicon Alloy). Type N thermocouples generally have high stability and resistance to high temperature oxidation which makes Type N suitable for high temperature measurements without the cost of platinum (B, R, 5) types. They can withstand temperatures above 1200 C°. Sensitivity is about 39 µV/° C. at 900° C., slightly lower than a Type K. Designed to be an improved type K, it is becoming more popular.

Thermocouple types B, R, and S are all noble metal thermocouples and exhibit similar characteristics. They are the most stable of all thermocouples, but due to their low sensitivity (approximately 10 µV/° C.) they are usually only used for high temperature measurement (>300° C.).

Type B—Platinum 30% Rhodium/Platinum 6% Rhodium. Suited for high temperature measurements up to 1800° C. Type B thermocouples (due to the shape of there temperature-voltage curve) give the same output at 0° C. and 42° C. This makes them useless below 50° C.

Type R—Platinum 13% Rhodium/Platinum. Suited for bight temperature measurements up to 1600° C. Low sensitivity (10 µV/° C.) and high cost makes Type R unsuitable for general purpose use.

Type S—Platinum 10% Rhodium/Platinum. Suited for high temperature measurements up to 1600°. Low sensitivity (10 µV/° C.) and high cost makes them unsuitable for general purpose use. Due to its high stability, Type S is used as the standard of calibration for the melting point of gold (1064.43° C.).

Type T—Copper/Constantan. Suited for measurements in the −200 to 350° C. range. Often used as a differential measurement since only copper wire touches the probes. As both conductors are non-magnetic, type T thermocouples are a popular choice for applications such as electrical generators which contain strong magnetic fields. Type T thermocouples have a sensitivity of ~43 µV/° C.

Type C—Tungsten 5% Rhenium/Tungsten 26% Rhenium. Suited for measurements in the 32 to 4208° F. (0 to 2320 C°). This thermocouple is well-suited for vacuum furnaces at extremely high temperature and must never be used in the presence of oxygen at temperatures above 500° F.

Type M—Nickel Alloy 19/Nickel-Molybdenum Alloy 20. This type is used in the vacuum furnaces as well for the same reasons as with type C above. Upper temperature is limited to 2500° F. (1400° C.). Though it is a less common type of thermocouple, look-up tables to correlate temperature to EMF (mini-volt output) are available.

A thermistor is a type of resistor used to measure temperature changes, relying on the change in its resistance with changing temperature, Thermistor is a combination of time words thermal and resistor. The thermistor was invented by Samuel Ruben in 1930, and was disclosed in U.S. Pat. No. 2,021,491.

If we assume that the relationship between resistance amid temperature is linear (i.e. we make a first-order approximation), then we can say that:

$$\Delta R = K\Delta T$$

Where:

ΔR change in resistance

ΔT=change in temperature

k=first-order temperature coefficient of resistance

Thermistors can be classified into two types depending on the sign of k. If k is positive, the resistance increases with increasing temperature, and the device is called a positive temperature coefficient (PTC) thermistor (Posistor). If is negative, the resistance decreases with in decreasing temperature, and the device is call a negative temperature coefficient (NTC) thermistor.

Thermistors differ from resistance temperature detectors in that the materials used in a thermistor is generally a ceramic or polymer, while RTDs use pure metals. The temperature response is also different; RTDs are useful over larger temperature ranges.

Other thermal technologies that can be employed include temperature sensors: thermometers, bi-metal thermometers and thermostats, heat sensors such as bolometers and calorimeter.

It is anticipated by the Applicant that various types of thermocouples or thermistors can be used for the present invention. It is not important what type of thermocouple or thermistor is utilized for monitoring or measuring the temperature of the water entering the shower head, bath head or water supply lines except that it is accurate for the appropriate temperature range monitored or measured.

In order to monitor or measure the flow rate of the water being delivered by the water supply line various flow measuring technologies are applicable to the present invention. For measuring or monitoring the rate of the water flowing through the shower or bath head, the use of various venturi type sensors or pressure sensors **74** as depicted in FIG. **4** are positioned in close proximity to the water to be measured.

One means to monitor flow parameter is to create a venturi, which constricts the flow in some fashion, and measure the differential pressure that results across the constriction. This method is widely used to measure flow rate in the transmission of gas or liquids trough pipelines, and has been used since Roman Empire times. The venturi effect is all example of Bernoulli's principle, in the case of incompressible fluid flow through a tube or pipe with a constriction in it. The fluid velocity must increase through

the constriction to satisfy the equation of continuity, while its pressure must decrease due to conservation of energy: the gain in kinetic energy is supplied by a drop in pressure or a pressure gradient force. The effect is named after Giovanni Battista Venturi, (1746-1822), an Italian physicist.

Using Bernoulli's equation in the special case of incompressible fluids (such as the approximation of a water jet), the theoretical pressure drop at the constriction would be given by the formula:

$$(\rho 2)(v_2^2-v_1^2)$$

In addition, the flow sensor **74** can be fabricated from pressure sensor technology. Pressure sensors are used in numerous ways for control and monitoring in thousands of everyday applications. Pressure sensors can be used in systems to measure other variables such as fluid/gas flow, speed, water level, and altitude. Pressure sensors can alternatively called pressure transducers, pressure transmitters, pressure senders, pressure indicators among other names.

Pressure sensors can vary considerably in technology, design, performance, application suitability and cost. A conservative estimate would be that there may be over 50 technologies and at least 300 companies making pressure sensors worldwide.

There are also a category of pressure sensors that are designed to measure in a dynamic mode for capturing very high speed changes in pressure. Example applications for this type of sensor would be in the measuring of combustion pressure in a engine cylinder or in a gas turbine. These sensors are commonly manufactured out of piezoelectric materials like quartz.

Some pressure sensors function in a binary manner, i.e., when pressure is applied to a pressure sensor, the sensor acts to complete or break an electrical circuit. Some speed cameras use them. These types of sensors are also known as a pressure switches.

In addition, various flow measuring technologies can be utilized as the flow sensor **74**. In general, a flow sensor is a device for sensing the rate of fluid flow. Typically a flow sensor is the sensing element used in a flow meter, or flow logger, to record the flow of fluids. There are various kinds of flow meters, including some that have a vane that is pushed by the fluid, and can drive a rotary potentiometer, or similar device. Other flow meters use a displacement piston, pushing it against a spring. Flow meters are related to devices called velocimeters that measure velocity of fluids flowing through them. Laser-based interferometry is often used for air flow measurement, but for liquids, it is often easier to measure the flow. Another approach is Doppler-based methods for flow measurement. Hall effect sensors may also be used, on a flapper valve, or vane, to sense the position of the vane, as displaced by fluid flow. A fluid dynamics problem is easily solved (especially in non-compressible fluids) by knowing the flow at all nodes in a network. Alternatively, pressure sensors can be placed at each node, and the fluid network can be solved by knowing the pressure at every node. These two situations are analogous to knowing the currents or knowing the currents at every node (noncompressible fluid being conserved in the same manner as Kirchoff's current or voltage laws, in which conservation of fluid is analogous to conservation of electrons in a circuit). Flow meters generally cost more than pressure sensors, so it is often more economical to solve a fluid dynamics network monitoring problem by way of pressure sensors, than to use flow meters.

In addition, there are several types of mechanical flow meters that can be utilized with the present invention as the flow sensor **74** that are listed below.

Piston Meter—Due to the fact that they used for domestic water measurement Piston meters, (also known as Rotary Piston, or Semi-Positive displacement meters) are the most common in the UK and are used for almost all meter sizes up to and including 40 mm (1½"). The piston meter operates on the principle of a piston rotating within a chamber of known volume. For each rotation, an amount of water passes through the piston chamber. Through a gear mechanism and, sometimes, a magnetic drive, a needle dial and odometer type display is advanced.

Woltmann Meter—Woltman meters, commonly referred to as Helix meters are popular at larger sizes. Jet meters (single or Multi-Jet) are increasing in popularity in the UK at larger sizes and are commonplace in the EU.

Dall Tube—A shortened form of the Venturi. Lower pressure drop than an orifice plate.

Orifice Plate—Another simple method of measurement uses an orifice plate, which is basically a plate with a hole through it. It is placed in the flow and constricts the flow. It uses the same principle as the venturi meter in that the differential pressure relates to the velocity of the fluid flow (Bernoulli's principle).

Pitot tube—Measurement of the pressure within a pitot tube in the flowing fluid, or the cooling of a heated element by the passing fluid are two other methods that are used. These types of sensors are advantageous in that they are rugged, so not easily damaged in an extreme environment. A pitot tube is an L shaped tube which is also able to measure fluid flow.

Paddle wheel—The paddle wheel translates the mechanical action of paddles rotating in the liquid flow around an axis into a user-readable rate of flow (gpm, lpm, etc.). The paddle tends to be inserted into the flow.

Pelton wheel—The Pelton wheel turbine (better described as a radial turbine) translates the mechanical action of the Pelton wheel rotating in the liquid flow around an axis into a user-readable rate of flow (gpm, lpm, etc.). The Pelton wheel tends to have all the flow travelling around it.

Turbine flow meter—The turbine flowmeter (better described as an axial turbine) translates the mechanical action of the turbine rotating in the liquid flow around an axis into a user-readable rate of flow (gpm, lpm, etc.). The turbine tends to have all the flow travelling around it.

Thermal mass flow meters—Thermal mass flow meters generally use one or more heated elements to measure the mass flow of gas. They provide a direct mass flow readout, and do not need any additional pressure temperature compensation over their specified range. Thermal mass flow meters are used for compressed air, nitrogen, helium, argon, oxygen, natural gas. In fact, most gases can be measured as long as they are fairly clean and non-corrosive.

Vortex flowmeters—Another method of flow measurement involves placing an object (called a shedder bar) in the path of the fluid. As the fluid passes this bar, disturbances in the flow called vortices are created. The vortices trail behind the cylinder in two rolls, alternatively from the top or the bottom of the cylinder. This vortex trail is called the Von Kármán vortex street after von Karman's 1912 mathematical description of the phenomenon. The speed at which these vortices are created is proportional to the flow rate of the fluid. Inside the shedder bar is a piezoelectric crystal, which produces a small, but measurable, voltage pulse every time a vortex is created. The frequency of this voltage pulse is also proportional to the fluid flow rate, and is measured by

the flowmeter electronics. With f=SV/L where, f=the frequency of the vortices L=the characteristic length of the bluff body V=the velocity of the flow over the bluff body S=Strouhal Number and is a constant for a given body shape.

In addition, various magnetic, ultrasound and Coriolis flow meters can be utilized with the present invention to function as the flow sensor **74**. Modern innovations in the measurement of flow rate incorporate electronic devices that can correct for varying pressure and temperature (i.e. density) conditions, non-linearities, and for the characteristics of the fluid. The most common flow meter apart from the mechanical flow meters, is the magnetic flow meter, commonly referred to as a "mag meter" or an "electromag". A magnetic field is applied to the metering tube, which results in a potential difference proportional to the flow velocity perpendicular to the flux lines. The physical principle at work is Faraday's law of electromagnetic induction. The magnetic flow meter requires a conducting fluid, e.g. water, and an electrical insulating pipe surface, e.g. a rubber lined non-magnetic steel tube.

Ultrasonic flow meters—Ultrasonic flow meters measure the difference of the transit time of ultrasonic pulses propagating in and against flow direction. This time difference is a measure for the average velocity of the fluid along the path of the ultrasonic beam. By using the absolute transit times both the averaged fluid velocity and the speed of sound can be calculated. Using the two transit times t_{up} and t_{down} and the distance between receiving and transmitting transducers L and the inclination angle α one can write the equations:

$$v = \frac{L}{2\sin(\alpha)}\frac{t_{up}-t_{down}}{t_{up}t_{down}} \text{ and } c = \frac{L}{2}\frac{t_{up}+t_{down}}{t_{up}t_{down}}$$

Where v is the average velocity of the fluid along the sound path and c is the speed of sound.

Measurement of the doppler shift resulting in reflecting an ultrasonic beam off the flowing fluid is another recent innovation made possible by electronics. By passing an ultrasonic beam through the water pipe, bouncing it off of a reflective plate then reversing the direction of the beam and repeating the measurement the volume of water flow can be estimated. The speed of transmission is affected by the movement of water in the supply pipe and by comparing the time taken to complete the cycle upstream versus downstream the flow of water through the supple pipe can be measured. The difference between the two speeds is a measure of true volume flow. A wide-beam sensor can also be used to measure flow independent of the cross-sectional area of the water pipe.

Coriolis flow meters—Using the Coriolis effect causes a laterally vibrating tube to distort, a direct measurement of mass flow can be obtained in a Coriolis flow meter. Furthermore, a direct measure of the density of the fluid is obtained. Coriolis measurement can be very accurate irrespective of the type of gas or liquid that is measured; the same measurement tube can be used for hydrogen gas and peanut butter without recalibration.

Laser-doppler flow meter. Fluid flow can be measured through the use of a monochromatic laser diode. The laser probe is inserted into a water pipe and turned on, where the light scatters and a small portion is reflected back to the probe. The signal is then processed to calculate flow within the water pipe. There are limitations to the use of a laser doppler probe; flow within a water pipe is dependent on volume illuminated, which is often assumed rather than measured and varies with the optical properties of the water pipe. In addition, variations in the type and placement of the probe within identical water pipes result in variations in reading. The laser doppler has the advantage of sampling a small volume of water, allowing for great precision, but does not necessarily represent the flow within an entire water system. The flow meter is more useful for relative rather than absolute measurements.

It is anticipated that the individual water sensors **95** can be installed at particular areas of the house, for example, the showers, the kitchen faucet, the bathroom faucets, the bathroom tub, the bathroom toilets, the washing machine, water heater, dishwasher and/or the outside irrigation system. In addition, additional outdoor water uses such as pool water maintenance (water addition), Jacuzzi, and water fountains can be included for water use monitoring. The individual water sensors **95** in different areas of a house (or corporation) can be transferred to an owner, individual user, corporate responsible individuals, government agencies or municipalities to review water use and water conservation information on a remote device, such as a cell phone, smart phone, or similar apparatus, or to a remote computer.

The flow sensors with **95** can communicate wirelessly or wired **94** with the microprocessor or microcontroller **84** that has software that learns about water usage at a particular station, home, and/or company. Calibration of the sensors with the base station **10**, **126** can be initiated by pressing hard buttons **114**, **116**, and **118** and/or software button activators **140**, **144**, and **146** on the base station **10**, **126**, or by the remote display and/or a recording apparatus **50**, and/or typical cell phones, smart phones and similar apparatus **40** can be located remotely from the base station **10**, **126**. In this embodiment, the multiple independent flow sensors **95** can communicate the independent water usage by wired or wireless communicating a unique code to the base station **10**, **126** that is programmed to calculate transfer of data for a specific period directly by the microprocessor or microcontroller **84** for processing. Then such water parameter information can be transfer to a remote source, e.g. remote display and/or a recording apparatus **50**, **110** and/or a typical cell phone, smart phone, or similar apparatus **400**, or to a remote computer. In this embodiment, the multiple flow sensors **95** can be engaged to the main water supply, irrigation system, washing machine, water heater, dishwasher, kitchen faucets, bathroom faucets, and/or toilets, and any combinations thereof, and send unique code data to the microprocessor or microcontroller **84** must be programmed through a calibration phase.

In another embodiment, an owner/user can enter a programmed "water use calibration mode" by pressing a specific hard or soft button on the base station **10**, **126** or touch screen display **80**, or sending an electronic signal from a display and/or recorded apparatus **50**, **110** and/or another remote device such as a cell phone, smart phone, or similar apparatus **400**, or to from a remote computer. Since independent water use apparatuses with associated water control valves and/or flow control mechanisms have unique flow rates, and pressure and sound patterns when closed or opened, the base station flow sensor, and the optional pressure sensor and optional acoustic/sound monitoring mechanism, can be incorporated into the base station **10**, **126** and function to assist identify the independent water use apparatus and its water control valve and/or flow control mechanism. In the first phase, while the base stations **10**, **126** is in the water use apparatus calibration mode, the user independently turns on one water use apparatus (e.g. wash-

ing machine) for a specified period and the calibration software monitors the flow rate, the optional pressure and optional sound patterns for that particular water use apparatus. The user continues these steps for each independent water use apparatus until all water use apparatuses desired to be monitored and are calibrated. The software can use the calibration data for each water use apparatus and record its water pattern or signature (actual independent flow rates, variation of flow rate over time, measured duration, variations in pressure patterns (e.g. pressure changes at onset of water flow and pressure changes when turned off, and any variations during water flow duration, and optional acoustic/sound frequency) to assign and record the pattern or signature of water use to a particular water use device. Then, when water use data can be communicated to a display and/or a recording apparatus **50**, **110** and/or cell phone, smart phone, or similar apparatus **400**, or to a remote computer, the independent flow rates and water use can be displayed appropriately in an graphic (e.g. pie) format (see FIG. **9**A).

It is anticipated by the Applicant that there can be an "Automatic Learning Mode" where the software learns about a owner's water use in a residence, corporation, building or structure over time without the calibration steps. In this embodiment, a single water flow sensor located at or in close proximity to the base stations **10**, **126** incorporates the automatic learning mode software. Since independent water use devices and their associated water valves and/or flow control mechanisms have unique flow rates, and pressure and sound patterns when being closed or opened, the base station flow sensor, and the optional pressure sensor and optional acoustic/sound monitoring mechanism, can be incorporated into the base station **10**, **126** and function to assist identify the independent water use device and its water control valve and/or flow control mechanism. A user can enter into a programmed "Automatic Learning Mode", by pressing a specific hard or soft button on the base station **10**, **126** or touch screen display **80**, or sending an electronic signal from a display and/or recorded apparatus **50**, **110** and/or another remote device such as a cell phone, smart phone, or similar apparatus **400**, or to a remote computer which initiates the software to monitor the water use that occurs during the next weeks or months, and during this period the software enters an automatic learning phase. In this phase, the base station with automatic learning mode software privately tracks an owner's water flow and volume use during each day, week and/or month, for each independent water use apparatus, monitoring and recording the water use at during different times of the day and days of the week. As one example, after a period of time, the automatic learning mode software monitors a washing machine and determines the range of water flow used and, records the water flow pattern or signature (actual independent flow rates, variation of flow rate over time, duration, variations in optional pressure patterns (e.g. pressure changes at onset of water flow and pressure changes when turned off, and any variations during water flow duration, and optional acoustic/sound frequency) during the duration of water use and determine timing parameters, and creates unique water use patterns or signature to identify the example washing machine water use. In another example, generally after a toilet is flushed, usually within a minute or two the bathroom faucet would turn on (to wash one's hands), the automatic learning mode software can identify the pattern, water use and timing parameters, and optionally use pressure and acoustic/sound frequency patterns to identify the both toilet(s) and bathroom faucet(s) water use. The automatic learning software could analyze, record, and store actual independent flow rates, variation of flow rate over time, typical durations, variations in pressure patterns (e.g. pressure changes at onset of water flow and pressure changes when turned off, and any variations during water flow duration, (and optional acoustic/sound frequency) to assign the unique patterns of water use for the toilet and bathroom faucet. In another example, either during or soon after a shower (and the software recognized the shower water use pattern), the hot water heater begins using water to replenish the hot water used for the shower. The automatic learning software can analyze, record and store actual independent flow rates, variation of flow rate over time, expected duration, variations in pressure patterns (e.g. pressure changes at onset of water flow and pressure changes when turned off, and any variations during water flow duration, (and optional acoustic/sound frequency) to assign the patterns of water use for both the shower and hot water heater. Irrigation watering usually occurs at a regular pattern (generally in the morning or evening hours) and the learning software could record and store flow and duration patterns for irrigation. The automatic learning software could record and store actual independent flow rates, variation of flow rate over time, expected duration, variations in pressure patterns (e.g. pressure changes at onset of water flow and pressure changes when turned off, and any variations during water flow duration, (and optional acoustic/sound frequency) to assign the unique patterns of water use for the, toilet, bathroom faucet, shower hot water heater, and irrigation system). Then, when water use data can be communicated to a cell phone, smart phone, or similar apparatus, or to a remote computer, and the independent flow rates and water use can be displayed appropriately in an graphic (e.g. pie) format (See FIG. **9**A).

In addition, as referred to in FIG. **6**, optionally sensitive flow sensor(s) **120***a*, **120***b*, **121** and **123**, **121** and **123** can be mounted at appropriate locations with monitoring software incorporated into either the flow sensors or the water use and water energy use monitoring display apparatus base station **10**, **126** can be employed to monitor leaks that are ascertained, that can communicate to the present invention water monitoring base station. A warning can be displayed on the first remote monitor or an immediate message can be sent to a programmed cell phone number by wireless communication means **46**, **52** and/or **54**. In this optional operation, a plurality of wireless or wired water very sensitive flow sensors **120***a*, **120***b*, **121** and **123**, **121** and **123** can be installed in close proximity of the supply lines, for example washing machines, sprinkler systems, refrigerator water supply lines, and other potential leaking sites. The water use and water energy use monitoring display apparatus base unit **10**, **126** periodically reads and stores data point water flow information corresponding to either a flow condition, no flow condition, or a slow flow condition through the supply line of the particular water fixture. Alternately, the pressure sensor can be in communication with the water supply line and can be used to determine leaks. For example, the water control valve can be turned off at a specified period of time to determine if the water pressure decreased, indicating a water leak condition. The water use and water energy use monitoring display apparatus base station **10**, **126** is configured to periodically receive a stream of stored data points from the at least one wireless flow sensor node by way of at least one coordinator node. The base station is configured to determine, based on an analysis of the stream of data points, whether a leak exists in at least one of the water fixtures. The water use and water energy use monitoring display apparatus base station **10**, **126** is designed, the when a leak is

detected, to provide a warning light, display, or alarm, or using the wired or wireless technology or third communication means **46**, **52** and/or **54**) to communicate the leak condition to a resident, commercial unit operator or manager, repair service person and/or municipal or governmental agency. The communication can be wirelessly transmitted by WIFI or cell format technology, microwave technology or satellite communication technology.

The base station **10**, **126** can be programmed to automatically send a signal to turn off the main water supply when a leak is sensed. If there are independent water control devices mount remotely from the base station **10**, **126**, the base station can communicate wirelessly or hard wired with the leak monitoring/control devices. With multiple sensors positioned around a residence or corporation, government agency or institution, it can also send out the location of the leak, e.g. at the washing machine, kitchen faucet, water heater. It is anticipated that a single water flow sensor located at the base station **10**, **126** can function to determine the presence of a leak. The single water flow sensor can be an invasive type, e.g. water turbine, impeller flow and/or paddle wheel, or non-invasive e.g. ultrasonic and/or magnetic flow sensor. The software can monitor the single flow sensor and if the water flow continues for a long period of time and is relatively continues in flow rate, the presence or a broken pipe, faucet left on, or water heater failure, other condition, an alarm can be initiated and then text or email messages sent to a cell phone, smart phone or similar apparatus, visual lights or audio sounds, and/or the water control means can shut off the main water supply to the residence or corporation. It is therefore an object of the present invention to providing a system whereby residential property owner or industrial/commercial owner may easily protect themselves against catastrophic damages caused by broken water pipes or leaking fixture.

In addition, as shown in FIG. **4**, is an optional halogen (chloride or fluoride) sensor **76**. There are currently several types sensors and technology are available on the commercial market that can be used with the present invention as chlorine and fluoride are common compounds or elements that are added to the water supply in an attempt to maintain clean water. The sensor **76** communicates with the water use and water energy use monitoring display apparatus base station apparatus **10**, **126** through wired **77** (or wireless means) which includes specific software instructions to display the halogen parameter on one of the displays or provide an alarm that is programmed that is triggered when an certain level or percentage is exceeded.

In addition, as shown in FIG. **4**, is an optional Total Dissolved Solids (TDS) sensor **78** measures are the total amount of mobile charged ions, including minerals, salts or metals dissolved in a given volume of water, expressed in units of mg per unit volume of water (mag/L), also referred to as parts per million (ppm). TDS is directly related to the purity of water and the quality of water purification systems and affects everything that consumes, lives in, or uses water, whether organic or inorganic, whether for better or for worse. "Dissolved solids" refer to any minerals, salts, metals, cations or anions dissolved in water. This includes anything present in water other than the pure water (H20) molecule and suspended solids. (Suspended solids are any particles/substances that are neither dissolved nor settled in the water, such as wood pulp.) In general, the total dissolved solids concentration is the sum of the cations (positively charged) and anions (negatively charged) ions in the water. Parts per Million (ppm) is the weight-to-weight ratio of any ion to water. A TDS sensor or meter is based on the electrical conductivity (EC) of water. Pure H20 has virtually zero conductivity. Conductivity is usually about 100 times the total cations or anions expressed as equivalents. TDS is calculated by converting the EC by a factor of 0.5 to 1.0 times the EC, depending upon the levels. Typically, the higher the level of EC, the higher the conversion factor to determine the TDS. TDS comes from organic sources such as leaves, silt, plankton, and industrial waste and sewage. Other sources come from runoff from urban areas, road salts used on street during the winter, and fertilizers and pesticides used on lawns and farms. Dissolved solids also come from inorganic materials such as rocks and air that may contain calcium bicarbonate, nitrogen, iron phosphorous, sulfur, and other minerals. Many of these materials form salts, which are compounds that contain both a metal and a nonmetal. Salts usually dissolve in water forming ions. Ions are particles that have a positive or negative charge. Water may also pick up metals such as lead or copper as they travel through pipes used to distribute water to consumers. Note that the efficacy of water purifications systems in removing total dissolved solids will be reduced over time, so it is highly recommended to monitor the quality of a filter or membrane and replace them when required. The sensor **78** communicates with the water use and water energy use monitoring display apparatus base station apparatus **10**, **126** through wired **79** (or wireless means) which includes specific software instructions to display the TDS parameter on one of the displays or provide an alarm that is programmed that is triggered when an certain level or percentage is exceeded.

The EPA Secondary Regulations advise a maximum contamination level (MCL) of 500 mg/liter (500 parts per million (ppm)) for TDS. Numerous water supplies exceed this level. When TDS levels exceed 1000 mg/L it is generally considered unfit for human consumption. A high level of TDS is an indicator of potential concerns, and warrants further investigation. Most often, high levels of TDS are caused by the presence of potassium, chlorides and sodium. These ions have little or no short-term effects, but toxic ions (lead arsenic, cadmium, nitrate and others) may also be dissolved in the water.

In addition, as shown in FIG. **4**, is an optional sensor **130** to measure or monitor the amount of metallic substances such as iron. Metallic or iron content in water can cause discoloration and other problems. It is anticipated by the Applicant that sensors for other metals, such as mercury, copper, silver, lead, or metallic elements can be utilized with the present invention. Mercury and lead consumption and exposure are known to be hazardous to humans. One method known to measure iron in a water sample is to use a Hall sensor biased with a magnet. As the sensor is positioned over the iron, more flux will pass through the Hall sensor. The sensor **130** communicates with the water use and water energy use monitoring display apparatus base station apparatus **10**, **126** through wired **131** (or wireless means) which includes specific software instructions to display the metallic or iron parameter on one of the displays or provide an alarm that is programmed that is triggered when a certain level or percentage is exceeded.

In addition, as shown in FIG. **4**, is a biological or fecal coliform (bacteria) sensor **132**. In general, increased levels of fecal coliforms provide a warning of failure water treatment, a break in the integrity of the distribution system, or possible contamination with pathogens. When levels are high there may be an elevated risk of waterborne diseases or gastroenteritis. The presence of fecal coliform in water system may indicate that the water has been contaminated

with the fecal material of humans or other animals. Fecal coliform bacteria can enter rivers or storm drains through direct discharge of waste from mammals and birds, from agricultural and storm runoff, and from human sewage. Failing home septic systems can allow coliforms in the effluent to flow into the water table, aquifers, drainage ditches and nearby surface waters and can contaminate wells or water systems. Sewage connections that are connected to storm drains pipes can also allow human sewage into surface waters. Some older industrial cities, particularly in the Northeast and Midwest of the United States, use a combined sewer system to handle waste. A combined sewer carries both domestic sewage and storm-water. During high rainfall periods, a combined sewer can become overloaded and overflow to a nearby stream or river, bypassing treatments. Pets can contribute to fecal contamination of surface waters. Runoff from roads, parking lots, and yards can carry animal wastes to streams through storm sewers. Birds can be a significant source of fecal coliform bacteria Agricultural practices such as allowing livestock to graze near water bodies, spreading manure as fertilizer on fields during dry periods, using sewage sludge bio-solids and allowing livestock watering in streams can all contribute to fecal coliform contamination. Some waterborne pathogenic diseases that may coincide with fecal coliform contamination include ear infections, dysentery, typhoid fever, viral and bacterial gastroenteritis, and hepatitis A and C. Reduction of fecal coliform in wastewater may require the use of chlorine and other disinfectant chemicals. Such materials may kill the fecal coliform and disease bacteria. They also kill bacteria essential to the proper balance of the aquatic environment, endangering the survival of species dependent on those bacteria. So higher levels of fecal coliform require higher levels of chlorine, threatening those aquatic organisms. Municipalities that maintain a public water supply will typically monitor and treat for fecal coliforms. In waters of the U.S., Canada and other countries, water quality is monitored to protect the health of the general public. In the U.S., fecal coliform testing is one of the nine tests of water quality that form the overall water-quality rating in a process used by U.S. EPA. However, in certain situations, such as septic systems, wells, and cross-contamination in plumbing distal to the site where water quality is tested, provides a risk. The fecal coliform assay should only be used to assess the presence of fecal matter in situations where fecal coliforms of non-fecal origin are not commonly encountered. EPA has approved a number of different methods to analyze samples for bacteria. The sensor **132** communicates with the water use and water energy use monitoring display apparatus base station apparatus **10**, **126** through wired **133** (or wireless means) which includes specific software instructions to display the fecal coliform parameter on one of the displays or provide an alarm that is programmed that is triggered when an certain level or percentage is exceeded.

The monitoring of fecal coliform and other contaminates may also become very important where many municipalities and cities are considering the use of sewage treated water, commonly known as grey water, and contamination may be useful in these situations.

In addition, as shown in FIG. **4**, is an optional pH sensor **134**. Various pH sensors available in the current market can be utilized with the present invention. The sensor **134** communicates with the water use and water energy use monitoring display apparatus base station apparatus **10**, **126** through wired **135** (or wireless means) which includes specific software instructions to display the pH parameter on one of the displays or provide an alarm that is programmed that is triggered when a certain level or percentage is exceeded.

In additional, as shown in FIG. **4**, is an optional water hardness sensor **136**. As pure water is a good solvent and picks up impurities easily and is often called the universal solvent. When water is combined with carbon dioxide to form very weak carbonic acid, an even better solvent results. As water moves through soil and rock, it dissolves very small amounts of minerals and holds them in solution. Calcium and magnesium dissolved in water are the two most common minerals that make water "hard." The degree of hardness becomes greater as the calcium and magnesium content increases and is related to the concentration of multivalent cations dissolved in the water. Hard water interferes with almost every cleaning task from laundering and dishwashing to bathing and personal grooming. Clothes laundered in hard water may look dingy and feel harsh and scratchy. Dishes and glasses may be spotted when dry. Hard water may cause a film on glass shower doors, shower walls, bathtubs, sinks, faucets, etc. Hair washed in hard water may feel sticky and look dull. Water flow may be reduced by deposits in pipes. Dealing with hard water problems in the home can be a nuisance. The amount of hardness minerals in water affects the amount of soap and detergent necessary for cleaning. Soap used in hard water combines with the minerals to form a sticky soap curd. Some synthetic detergents are less effective in hard water because the active ingredient is partially inactivated by hardness, even though it stays dissolved. Bathing with soap in hard water leaves a film of sticky soap curd on the skin. The film may prevent removal of soil and bacteria. Soap curd interferes with the return of skin to its normal, slightly acid condition, and may lead to irritation. Soap curd on hair may make it dull, lifeless and difficult to manage. When doing laundry in hard water, soap curds lodge in fabric during washing to make fabric stiff and rough. Incomplete soil removal from laundry causes graying of white fabric and the loss of brightness in colors. A sour odor can develop in clothes. Continuous laundering in hard water can shorten the life of clothes. In addition, soap curds can deposit on dishes, bathtubs and showers, and all water fixtures. Hard water also contributes to inefficient and costly operation of water-using appliances. Heated hard water forms a scale of calcium and magnesium minerals that can contribute to the inefficient operation or failure of water-using appliances. Pipes can become clogged with scale that reduces water flow and ultimately requires pipe replacement.

The hardness of your water is generally reported in grains per gallon, milligrams per liter (mg/l) or parts per million (ppm). One grain of hardness equals 17.1 mg/l or ppm of hardness.

The Environmental Protection Agency establishes standards for drinking water which fall into two categories—Primary Standards and Secondary Standards.

Primary Standards are based on health considerations and Secondary Standards are based on taste, odor, color, corrosivity, foaming, and staining properties of water. There is no Primary or Secondary standard for water hardness. Water hardness is classified by the U.S. Department of Interior and the Water Quality Association as follows:

Classification	mg/l or ppm	grains/gal
Soft	0-17.1	0-1
Slightly hard	17.1-60	1-3.5
Moderately hard	60-120	3.5-7.0
Hard	120-180	7.0-10.5
Very Hard	180 & over	10.5 & over

NOTE:
Other organizations may use slightly different classifications.

The sensor **136** communicates with the water use and water energy use monitoring display apparatus base station apparatus **10**, **126** through wired **13** (or wireless means) which includes specific software instructions to display the pH parameter on one of the displays or provide an alarm that is programmed that is triggered when an certain level or percentage is exceeded. The water parameter use and monitoring apparatus can use a typical cell phone, smart phones, or similar apparatus includes an application (APP) for a consumer/resident, corporate entity, or municipality that show water quality parameters.

Now referring to FIG. **5**, which presents a more detailed example **110** of the first remote display and/or recording apparatus **50** or the second optional (handheld) display and/or recording apparatus **56**. The first display/recording apparatus **50** or optional second (handheld) display and/or recording apparatus **56**, represented as apparatus **110**, includes a housing or container **112**, display means **114**, **116**, and **118** and/or software control buttons **140**, **142**, and **144**, the electronic circuit board (microprocessor) with wire or wireless capability, and power source which are common components between the two display and/or recording apparatuses. It is also anticipated that an optional third display/recorder (not shown) could utilized with computer or television that has an internet, intranet, wire or wireless means. In addition, it is anticipated by the Applicant that the first **50**, second **56** and third display recorders could be a typical cell phone, smart phones, or similar apparatus includes all remote cellular phones using channel access methods defined above (with cellular equipment, public switched telephone network lines, satellite, tower and mesh technology), mobile phones, PDAs, tablets (e.g. refers to all current and future variants, revisions and generations of the Apple IPAD, Samsung Galaxy, HP, Acer, Microsoft, Nook, Google Nexus, Sony, Kindle and all future tablets manufactured by these and other manufactures), Apple IPOD Touch, a smart or internet capable television, wireless timepiece or wireless watch (Apple, Samsung) and other similar apparatus with WIFI and wireless capability, and remote computers and controllers having internet, wireless and/or cell format technology connectivity.

In this first display/recorder **50**, the second display/recorder **56**, or the third computer, televisions or a typical cell phone, smart phones, or similar apparatus can utilize custom software and/or market software that will be used to transfer the water parameter information from the primary or secondary water/energy use monitoring display apparatus **10**, **126** to the first display and/or recording apparatus **50**, the second display and/or recording apparatus **56**, or the third computer or television.

The example of the first remote display and/or recording apparatus **50**, or the second remote display/recording apparatus **56**, represented as apparatus **110**, includes within the housing or container **112**, a computerized circuit board (depicted in FIG. 3), that communicates with the one or more display means **114**, **116**, and **118**. The housing **112** can have an optional door for replacing a battery power source or removable data chip, or electrical connector for regenerating the power source. The apparatus **110** has a plurality of buttons **120**, **122**, and **124** and/or software buttons or activators (e.g. touch screen) **140**, **142**, **144** that allow for certain modification of the software instructions (change units, change language, change from metric to US standard, set alarms, initiate communication with wired or wireless means). While FIG. **5** shows three hard buttons **114**, **116**, and **118** and six software button activators **140**, **144**, and **146**, it is anticipated by the Applicant that a different series of hard or software buttons can be used, and/or a different series of software button sequencing can be utilized. For example, other hard button technology can be used, such as a rotary switches or multiple membrane switch technology. The housing or container **112** can be fabricated from a metallic material such as brass, brass alloys, steel, galvanized steel, copper, copper allows or any combination thereof. The display means housing can be fabricated from a number of polymeric materials, such as polyvinyl chloride (PVC), polyethylene, polybutylene, acryaontirile-butadiene-styrene (ABS), rubber modified styrene, polypropylene, polyacetal, polyethylene, or nylon. The base material can be painted white or colored finishes or coated with various brass, silver and gold type materials to accommodate the match with various presently marketed finishes. The material for fabricating the housing **112** is not particularly important except and the size of the display means will generally determine the size of the housing but it does not have to be substantially rectangular as shown, any number of geometric configurations could be used in the present invention.

The plurality of display means **114**, **116**, and **118** and as presented in FIG. **5** utilizes one or more illuminating technologies, such as LCD, LED, gas plasma, fluorescence, incandescent, halogen, halide, or other lighting technologies but should be able to provide sufficient lighting for observing the data and information in dark conditions. In addition, the display means and display means housing should be able to sustain capability in moist wet conditions. The present invention can include one or more than one display means to show various water use and water energy use parameters. Provided only as an example, display means **114**, **116**, and/or **118** can display different levels of water use with a color hue or format providing a visual cue or water use or alarm conditions. For example, a green background or parameter digits for a 1^{st} hundred cubic feet (e.g. a first 14 HCF) level, yellow background or parameter digits for a 2^{nd} hundred cubic feet (a second 14 HCF) level, and red background or parameter digits for a 3^{rd} hundred cubic feet (28 HCF) level, can be displayed. For example, the other embodiment with only the flow and water use display can be manufactured to reduce overall costs. Furthermore, the orientation of the water use and water energy use parameters can be presented in various formats. For example, the flow parameter can be on top **114** with the date parameter on the bottom **118** and with the energy parameter sandwiched between **116**. The displays **114**, **116**, and **118** can have a background light or parameter alpha-numeric digits that is used for various purposes, for example, for providing better lighting conditions or changing colors e.g. from green to yellow and to red, to display alarming condition (e.g. water use over time has exceed a certain level). Displaying of all water and water energy parameters can utilize a gang multiple LCD, LED, gas plasma, fluorescence, incandescent, halogen, halide, or other lighting technologies separate displays, custom displays, graphic displays or a single line display which sufficient digits that sequences the presentation of the water parameters and water energy parameters one at a time with

a specific delay and sequencing. An example of a LCD unit that can be used with the present invention is the color graphic 128×128 LCD-00569 marketed by Sparkfun Electronics in Boulder, Colo. Digitikey, Mouser and other electronic supply warehouses have many other variants and other LCD, LED, gas plasma, fluorescence, incandescent, halogen, halide, or other lighting technologies that can be utilized with the present invention.

The display means **114**, **116**, and **118** can be programmed to display one or more parameters in a visual means that can be either an analog, character or digital display, or combination of display means. Information obtained from the appropriate sensor monitoring or measuring the water parameters such as temperature, date/time, and flow rate can be displayed in an appropriate format on the display means. For example, when a sensor is monitoring or measuring the rate of water flowing from a water source or through the shower head, the display means could show any flow between 0 gal/min (0 liters/min) to many thousands of gals/day. For example, when a sensor is monitoring the shower temperature of water flowing through the housing, the display means could show any energy ratio calculation that takes into effect the overall temperature and total volume of heated water vs. the total volume of cold or ambient water. It is anticipated by the Applicant that many different water energy calculations might be utilized by the present invention. Furthermore, the display can be programmed to display calendar information, such as the date and current time (12 hr. or 24 hr. format).

It is anticipated by the Applicant the present invention can be fabricated and marketed with one, two or more display means. For example, a lower cost display assembly can be fabricated and sold that only has a temperature sensor and temperature display means. A more expensive display assembly can be fabricated and sold that has temperature, flow, timing and other sensors with various programmed methods and a shut off mechanism.

Also shown in FIG. **5**, one or more ergonomically **120**, **122**, **124** placed buttons or activators which can be incorporated into the display means housing or container or touch screen software buttons **140**, **142**, and/or **144** to allow the modification of certain parameter units (e.g. metric to US), set alarm conditions (e.g. flow/volume rate-set points), or to program certain settings, e.g. over water use alarm, monitor continuous leakage (valve not complete shut off). The buttons will electrically communicate with the electronic circuit board and microprocessor **84** contained within the housing or container **112** and respond to programmed instructions integrated within the CPU or microprocessor **84** and associated circuitry of the electronic circuit board. The buttons or activators **120**, **122** and/or **124** should be mounted with the display means housing or container **112** with the capability to protect the buttons and electronic circuitry with the housing for exposure to moist and wet conditions. It is also an alternative design to use touch sensitive display means or touch screen technology.

Also as shown in FIG. **3** but applicable to FIG. **5**, is an CPU or microprocessor **84** and associated circuitry mounted on a electronic circuit board with a power source and contained within the first remote display and/or recording apparatus **50**, or the second remote display and/or recording apparatus **56**. The microprocessor **84** controls the display and/or recording apparatuses and communicates with the sensors. The CPU or microprocessor **84** and associated circuitry mounted on the electronic circuit board can also have the capability to be programmed for controlling certain display means (e.g. U.S. or metric units), programming certain alarm or setting states (e.g. flash all display means red when the total volume has exceeded a certain volume, for example, 150 gallons/day).

Now referring to FIG. **6** is a perspective view home **119** having of a plurality of optional sensitive water flow sensors with one-way transmission, half duplex or full duplex transceivers **120***a*, **120***b*, **121** and **123**, attached to various locations for monitoring water use and furthermore for monitoring for water leaks in addition to the flow sensor **74**.

In regard to FIG. **6**, the wireless data transfer or communication means can use radio-frequency, Bluetooth, ZigBee, WiFi, optical or other wireless technology for transferring the water parameter data generated by the water use, water energy and water quality sensors and collected by the microprocessor **84** and sent to a remote display and/or recording apparatus **50**, **56**. Display and/or recorder receiver apparatus **50**, **56** can have the function allows an individual or entity to review that data for auditing or monitoring purposes. Examples of Bluetooth modules (using the 2.4 GHz band as WiFi) that can be added to the present invention are the RN-41 Bluetooth modules available from Roving Networks in Los Gatos, Calif., the KC-41, KC 11.4, KC-5100, KC-216 or KC-225 data serial modules from KC Wireless in Tempe Ariz., and/or the BT-21 module from Amp'ed RF wireless solutions in San Jose, Calif. Examples of wireless protocols that can be utilized with the present invention include, but are not limited to, the IEEE 802.11a, IEEE 802.11b, IEEE 802.11g and IEEE 802.11n modulation techniques. Another example of the wireless protocols that can be utilized with the present invention is the ZigBee, Z-wave and IEE 802.15.4 modulation technology. Applicants recognize that there are numerous wireless protocols that have been developed that, although not specifically listed, could be utilized with the present invention for data transfer purposes.

In addition, the wireless or wire data transfer can be connected to the Internet using the IP or DHCP protocols whereby the data can be monitored remotely over the Internet using a software program designed to record, display, analyze and/or audit the water parameter data. The present invention would probably have to "log on" to a server to report the water parameters or it could respond to queries once its presence is known to the server.

Also some wireless routers support a form of "private" point-to-point or bridging operation which could be used to transfer water parameter data from the present invention to a receiving apparatus. Other kinds of proprietary protocols to be used with the present invention are possible as well. For example, there is the ISM (industrial, scientific and medical) bands. The ISM bands are defined by the ITU-R in 5.138, 5.150, and 5.280 of the Radio Regulations. Individual countries' use of the bands designated in these sections may differ due to variations in national radio regulations. Because communication devices using the ISM bands must tolerate any interference from ISM equipment, these bands are typically given over to uses intended for unlicensed operation, since unlicensed operation typically needs to be tolerant of interference from other devices anyway. In the United States of America, ISM uses of the ISM bands are governed by Part 18 of the FCC rules, while Part 15 Subpart B contains the rules for unlicensed communication devices, even those that use the ISM frequencies. Part 18 ISM rules prohibit using ISM for communications.

The ISM bands defined by the ITU-R are:

Frequency range [Hz]	Center frequency [Hz]
6.765-6.795 MHz	6.780 MHz
13.553-13.567 MHz	13.560 MHz
26.957-27.283 MHz	27.120 MHz
40.66-40.70 MHz	40.68 MHz
433.05-434.79 MHz	433.92 MHz
902-928 MHz	915 MHz
2.400-2.500 GHz	2.450 GHz
5.725-5.875 GHz	5.800 GHz
24-24.25 GHz	24.125 GHz
61-61.5 GHz	61.25 GHz
122-123 GHz	122.5 GHz
244-246 GHz	245 GHz

While currently the 430 MHz and 900 MHz frequencies are commonly used in the US, it is anticipated by the Applicants that the other frequencies could be used for water parameter transfers.

Another protocol known as CAN or CAN-bus (ISO 11898-1) that was originally designed for automotive applications, but now moving into industrial applications is another type of network that could be used to transfer water parameter data. Devices that are connected by a CAN network are typically sensors, actuators and control devices. A CAN message never reaches these devices directly, but instead a host-processor and a CAN Controller is needed between these devices and the bus.

It is anticipated by the Applicant that the present invention water parameter use display and monitoring device utilizing the said wireless communication with the one or more remote display and/or recorder apparatus can automatically convert back and forth from radio frequency format, ZigBee or Bluetooth format to a cellular format technology to accommodate different range requirements.

The present invention can also use RF mesh technology, which allows meters and other sensing devices to securely route data via nearby meters and relay devices, creating a "mesh" of network coverage. The system supports two-way communication between the water use and water energy use monitoring display apparatus base station **10** (and **126** in FIG. **6**) and the remotely positioned display and/or recorder receiver apparatus **50**, **56** and can be upgraded remotely, providing the ability to implement future innovations easily and securely.

The electric network access point collects data and periodically transfers this data to defined municipality via a secure cellular network. Each RF mesh-enabled device (meters, relays) is connected to several other mesh-enabled devices, which function as signal repeaters, relaying the data to an access point. The access point device aggregates, encrypts, and sends the data back to municipality or governmental agency over a secure commercial third-party network. The resulting RF mesh network can span large distances and reliably transmit data over rough or difficult terrain. If a meter or other transmitter drops out of the network, its neighbors find another route. The mesh continually optimizes routing to ensure information is passed from its source to its destination as quickly and efficiently as possible.

Furthermore, the present invention can communicate utilizing optical technology and other wireless networks such a cell phone technology or private networks.

The transfer of data or information through wired or wireless technology can be initiated using a "wake up" button or signal from a first or second remote display/recorder.

Also shown in FIG. **6** is another embodiment of the present invention whereby the water energy use monitoring display apparatus base station **126** is in close proximity to the pressure regulator or pressure reduction valve **124**. It is anticipated by the Applicant the water use and water energy use monitoring display apparatus base station apparatus **126** can be incorporated into a pressure regulator (pressure reduction valve) or water meter to provide single apparatus the replaces the water meter or pressure regulator (pressure reduction valve). It is also anticipated by the Applicant that when the water use monitoring display apparatus base station **126** is in close proximity to the highly sensitive flow sensor e.g. the irrigation flow sensor **121**, the electrical connection or communication can be hard wired. The typical locations for the highly sensitive water flow sensors with transceivers **120***a*, **120***b*, **121** and **123** (and any additional flow sensors) are at the water input supply lines for a typical washing machine **128**, a sprinkler system **122**, the at the pressure regulator or water pressure reduction valve **124** or at the shower head **122**. The very sensitive flow sensors with transceivers **120***a*, **120***b*, **121** and **123** can also be located on water using appliances such as sinks, toilets, hot water heaters, clothes washers, bathtubs, and the like.

The use of water flow sensors on the irrigation water source and other outdoor water sources can function to provide independent outdoor water data. The use of indoor water use (data acquired by the installed base system **10** or **126**) and outdoor water (data acquired by sensor **121** at irrigation supply **122** use can be individually monitored. This can be useful for an individual or commercial operator to employ water conservation methods (e.g., reduce the sprinkler frequency or duration). Alternately, the monitoring of indoor water use and outdoor water use could be utilized by the particular water supplying municipality or government agency to apply different rates for indoor water use and outdoor water use. Furthermore, since many municipalities change a sewer fee that is calculate as a ratio of the total water use, the monitoring of indoor water use versus outdoor water use can reduce the sewer fees for consumers. In sever situations, a control valve can be located at a particular location, e.g. at the irrigation valve **122** whereby by utilizing the two-way duplex wireless capability through communication means **46** and **54** of the water use and water energy use monitoring display apparatus **10**, **126**, the water supplying municipality or government agency can remotely control water use (e.g. send out a code that inhibits outdoor water use on certain days or at certain hours of the day).

The highly sensitive flow sensors with transceivers **120***a*, **120***b*, **121** and **123**, should be designed to determine if the flow is occurring through a particular water fixture is as slow as, for example, 25-50 ml per minute. The highly sensitive flow sensors with transceivers **120***a*, **120***b*, **121** and **123** can be programmed to periodically detect slow flow or no flow conditions at particular time intervals, such as, for example, every 10 to 45 seconds. Alternately the water parameter data can be recorded and stored at individual high flow sensor for subsequent transmission as a stream of data points or a data packet. In this regard the recorded data can be transmitted wirelessly to the base station **10**, **126** at longer programmable time intervals, such as, for example, every 24 hours. The highly sensitive flow sensor with transceivers **120***a*, **120***b*, **121** and **123** are designed as wireless flow sensors and designed to have very low electrical power usage. Power consumption for each highly sensitive water flow sensor with transceivers **120***a*, **120***b*, **121** and **123** are designed to be extremely low, for example, about 100-200 micro-amp

hours per day. Power can be supplied by batteries, or alternatively, can be connected to the 120/240 volt electrical system. The highly sensitive water flow sensors with transceivers **120***a*, **120***b*, **121** and **123**, can have an extended battery life by utilizing the interval wireless communications or transmissions and with a long lasting battery pack, such as, for example, the Tadiran series of batteries manufactured by Tadiran U.S. Battery in Lake Success, New York. A sealed door means is utilized to allow battery replacement. In addition, the batteries can be recharging type and accessed with a electrical coupler accessed from the outside of the highly sensitive flow sensors with transceivers **120***a*, **120***b*, **121** and **123**.

The flow sensor with transceivers (and any additional flow sensors) can be electrically coupled with a microprocessor or microcontroller that has software that learns about water usage at a particular station, home, and/or company. In this embodiment, multiple flow sensors **120***a*, **120***b*, **121** and **123** (and any additional flow sensors) can communicate wirelessly or wired with the base station **10**, **126** that has software the learns about water usage at particular station, home and/or company. A user can enter a programmed "leak monitoring stage", that promptly compels base station **10**, **126** to search for and initiate wireless communication with each independent flow sensors (e.g. flow sensors for the water supply, irrigation system, washing machine, water heater, dishwasher, kitchen and bathroom faucets, toilets, and showers), times when you are home and not home, and remembers the different water use you use at during different times of the day and days of the week. For example, after a period learning the individual flow sensor(s) water use, the software has monitored the washing machine and determined the range of water flow used during the duration of washing cycles and determine timing parameters, such as the washing machine is generally used between 8:00 a.m. to 1:00 p.m. In this example, if a small or large flow that occurs outside of this recorded ranges could send out a warning or alarm. For example, if water is flowing on the washing machine at 1:00 a.m., and appropriate warning or alarm can be generated. In another example, the flow sensor connected to the kitchen faucet can determine the average rate of flow and associated timing parameters. If the kitchen faucet senses that the kitchen faucet has been on outside of the normal range, e.g. for 30 minutes continuous, and if this occurs at times outside of the normal range, after 10:30 p.m., a warning or alarm can be generated. Furthermore, during sleeping hours, water generally in not flowing, except for occasional toilet user. The base station **10**, **126** can monitor the flow sensors during the night when occupants are sleep and if a water flow condition occurs, a warning or alarm can be generated. In this capacity, the highly sensitive flow sensor with transceivers **120***a*, **120***b*, **121** and **123** (and any additional flow sensors) function as both a flow sensor and a leak detection sensor. The software can also determine is the water flow is on for a long and constant or continuous duration (e.g. 25 minutes), whether it is a high flow or low flow, the base station **10**, **126** can determine that a leak is possible and can send an alarm, text, email or other signal to the user or municipality, or turn off the water supply.

At the water use and water energy use monitoring display apparatus/base station **10**, **126**, (**200**) received data can be stored and analyzed to determine whether any water fixture in the facility is leaking by monitoring differentiates between normal flow conditions and a slow flow condition. When or if leakage condition is indicated, an alert can be generated on the various displays associated with the water use and water energy use monitoring display apparatus base station **10**, **126** and/or initiate a call, using wireless network **44**, can be made to the home or office owner/operator or to the municipality or governing agency so that maintenance personnel can be dispatched to turn-off the water supply at the offending residence or office or fix the leaking unit. The data and/or results of analysis conducted at the water use and water energy use monitoring display apparatus base station **10**, **126** can be transmitted to a remote central monitoring computer service via satellite, microwave technology, the internet, telephone lines, and the like. At the off-site location, additional analysis and/or monitoring can be accomplished.

The sensitive flow sensors with transceivers are designed to have coordination between the water use and water energy use monitoring display apparatus base station **10**, **126** by using software instructions for timing, network position, and polling operations. For example, the water use and water energy use monitoring display apparatus base station **10**, **126** can first send a broadcast message to, for example, one or more sensitive flow sensors with transceivers. The broadcast message can instruct the highly sensitive flow sensors with transceivers to, for example, synchronize themselves in the system, set their clocks, and identify their wireless path to the water use and water energy use monitoring display apparatus base station **10**, **126**. After receiving the broadcast message, the water use and water energy use monitoring display apparatus base station **10**, **126** can send an acknowledgement back to the water use and water energy use monitoring display apparatus base station **10**, **126** revealing their location in the system. Hence an alert can be generated on the various displays associated with the water use and water energy use monitoring display apparatus base station **10**, **126** and/or initiate a call, using wireless network **44**, or cell phone can be made to the home or office owner/operator or to the municipality or governing agency so that maintenance personnel and convey the flow sensor that has detected a leak (e.g. irrigation system, washing machine hose, water heater, dishwasher, kitchen and bathroom faucets).

The water use and water energy use monitoring display apparatus base station **10**, **126** can also communicate with the sensitive flow sensors with transceivers to include software instructions for programming time intervals for water parameter data transmission.

Coordination of data packet transmissions from the sensitive flow sensors **120***a*, **120***b*, **121** and **123** (and any additional flow sensors) can be scheduled. The water use and water energy use monitoring display apparatus base station **10**, **126** can run a master schedule for querying each flow sensor. For example, the water use and water energy use monitoring display apparatus base station **10**, **126** can transmit a message to a specific coordinator node **18** and that coordinator node can then sequentially request data from each of its flow sensors. This systematic process can reduce data packet collision on the network and can make the use and water energy use monitoring display apparatus base station **10**, **126** immediately aware of any flow sensor that might be having trouble transmitting its data packet.

The software in the water use and water energy use monitoring display apparatus base station **10**, **126** to perceive water flow characteristics in the facility for a given unit of time, such as, for example, a day, for every unit in the facility. The software should be designed to identify numerous conditions, such as, for example, faulty toilet valves, periodic and irregular water flow for example toilets, faucets, and a slow constant water flow, a characteristic of a leakage condition.

In additionally, the base station **10**, **126** can be programmed such that when a leak condition is detect by one of the highly sensitive flow sensors **120***a*, **120***b*, **121** and **123** (and any additional flow sensors), the base station **10**, **126** will automatically turn off the main water supply.

Water energy use was defined herein as to the ratio of cold or ambient water use to heated water use or to the ratio of hot water use to water flow use. However, the Applicant contends that many other water energy calculations can be programmed for use with the present invention. For example, a commonly known energy calculation such as the "Energy Factor" which includes the ratio of useful energy output from the water heater to the total amount of energy delivered to the water heater might be used with the ratio of total volume of hot water (including the temperature of the hot water monitored over a time period) and total volume of cold or ambient are taken into consideration, resulting in another energy calculation. There are some websites (paystolivegreen.com) that provides a water and energy calculator as shown below which could be used with the present invention. As shown in FIG. **7** is an example of a water energy data format that uses cold/ambient water and hot water to provide water usage and water energy costs. The Applicant contends that many different water energy calculations can be used with the present invention without deviated from its intended use. The water parameter use and monitoring apparatus can communicate with a said typical cell phone, smart phones, or similar apparatus includes an application for a consumer/resident, corporate entity, or municipality that show the daily, weekly and/or monthly water use and/or daily, weekly or monthly water costs.

The water use and water energy use monitoring display apparatus base station **10**, **126** can transmit an acknowledgement to each highly sensitive flow sensors **120***a*, **120***b*, **121** and **123** after successfully processing a data packet.

Shown in FIG. **8** is a perspective view of a first example application (APP), or a first page of a application (APP) **300**, displayed on a typical cell phone, smart phone or similar apparatus **400** (see FIG. **9**). This example application (APP) or page **300** is designed as a line graph format to be used by the resident of a home or a representative of a company or a corporation to monitor water conservation, but is it anticipated by the Applicant that the application (APP) **300** could be used by municipal or government representatives.

FIG. **8** shows and example of a first application or page (APP) **300** for Water Use **302** having a daily **304** graph. **306** with day hours **308**, designated by the symbol AM **312** and the night hours **310** designated by the symbol PM **314**. At the right side of the example first application or page (APP) **300** is the daily total use of water **316** and the daily total cost in dollars (or other currency) **318** that has been downloaded the data **340** from the registered or serving water municipality. Within the daily graph **306** is a plotted line **307** that shows the hourly water use. The plotted line **307** can have a rolling feature whereby new data replaces the oldest data in the graph. A gallon or liter scale can be included on the left side of the daily graph **305** (not shown).

The example of a first application or page (APP) **300** for Water Use **302** can also have a weekly **320** graph **322** with days **324**. At the right side of the example first application or page (APP) **300** is the weekly total use of water **326** and the weekly total cost in dollars (or other currency) **328** that has been downloaded the data **340** from the registered or serving water municipality. Within the weekly graph **322** is a plotted line **327** that shows the daily water use. The plotted line **327** can have a rolling feature whereby new data replaces the oldest data in the graph. A gallon or liter scale can be included on the left side of the weekly graph **322** (not shown).

The example of a first application or page (APP) **300** for Water Use **302** can also have a monthly **334** graph **330** with months **332**. At the right side of the example first application or page (APP) **300** is the monthly total use of water **336** and the monthly total cost in dollars (or other currency) **338** that has been downloaded the data **340** from the registered or serving water municipality. Within the monthly graph **330** is a plotted line **337** that shows the daily water use. The plotted line **337** can have a rolling feature whereby new data replaces the oldest data in the graph. A gallon or liter scale can be included on the left side of the monthly graph **330** (not shown).

The present invention water parameter use display and monitoring device **10**, **126** is designed to transfer data and information by utilizing the wireless communication with the one or more remote display and/or recorder apparatus, or cell phone, smart phone or similar apparatus whereby the remote display and/or recorder apparatus or cell phone, smart phone or similar apparatus can automatically convert back and forth from radio frequency format, ZigBee or Bluetooth format to a cellular format technology to accommodate different range requirements. The typical cell phone, smart phones, or similar apparatus with wireless communication can automatically convert back and forth from radio frequency format, ZigBee or Bluetooth format to a cellular format technology to accommodate range requirements.

Also shown in FIG. **8** is a Download Button **340** which is designed to manually or automatically download water rate and expense data from the servicing and registered water municipality or other source. The cost per gallon, hundred cubic feet (HCF) or other measurement is usually dependent on volume used over a given period. For example, from 0-8 HCF could be billed at $3.64 per HCF, 9-24 HCF could be billed at $4.08 per HCF, and 25-36 HCF could be billed at $5.82 per HCF. This is only an example data that can be downloaded and utilized to determine the daily cost **318**, weekly cost **328**, or monthly cost **338**. Other data can be downloaded from the water municipality or other source such as warnings for drought conditions, metering policies, quality messages, limits, alarms, etc.

Also shown in FIG. **8** is a user, whether it is a home owner or company representative, who can Set Limits **342** for water use to command the water use and water energy use monitoring apparatus base station **10**, **126** to turn the water completely off, limit the flow, or sound a verbal or audio alarm. It is anticipated that the servicing and registered water municipality or other source can upload Set Limits **342** to the individual water use and water energy use monitoring apparatus base station **10**, **126**. It addition, the Set Alarms **344** for water use can be used to display visually or provide audio signals of alarming conditions associated with the daily, weekly or monthly water use. The application (APP) **300** is designed to promote water conservation and monitor for leaking conditions.

Also shown on the FIG. **8** is an optional Water Quality section **350** of the application (APP) **300**. As shown, optional water quality Sensor **1** **352** can monitoring one or more halogen elements or compounds, monitoring total dissolve solids, monitoring a metallic or iron element or compound, monitoring water hardness, monitoring biological or coliform contaminates, monitoring pH, or any combinations thereof. The plotted line **358** for Sensor **1** shows peaks and valley over the time period **360**. The time period can be selected for daily, weekly or monthly. Sensor **2** **354**,

can be another water quality sensor and Sensor X **356** can be one or more water quality sensor taken from the group define above.

Shown below in this optional Water Quality section **350**, is a Frequency Soft Button which allows the user to define the time period, daily, weekly or monthly. A user, whether it is a home owner or company representative, who can Set Limits **372** for water quality to command the water use and water energy use monitoring apparatus base station **10**, **126** to turn the water completely off, limit the flow, or sound a verbal or audio alarm. It is anticipated that the servicing and registered water municipality or other source can upload Set Limits **372** to the individual water use and water energy use monitoring apparatus base station **10**, **126**. It addition, the Set Alarms **374** for water use can be used to display visually or provide audio signals of alarming conditions associated with the daily, weekly or monthly water use.

As FIG. **8** is only an example of presentation of the water use and water quality data, it is anticipated that other formats for displaying the daily, weekly, monthly, or annual water use and water quality use. Such formats can be in bar graph format, pie graph format, cosmograph formats, time series graph formats, histogram formats, data plot format, scatter plot format, other graph formats, or a combination of these graph formats.

Shown in FIG. **9A** is another "APP" or another "APP" page can show, in a pie chart, bar chart, or other format, show the individual water use at particular areas of the house, for example, the showers, the kitchen faucet, the bathroom faucets, the bathroom tub, the bathroom toilets, the washing machine, water heater, dishwasher and/or the outside irrigation system, in addition, outdoor water uses such as pool water maintenance (water addition), Jacuzzi, and water fountains can be included for water use monitoring. The individual water use in different areas of a house (or corporation) can be transferred to an owner, individual user, corporate responsible individuals, government agencies or municipalities to review water use and water conservation information on a remote device, such as a cell phone, smart phone, or similar apparatus, or to a remote computer. Leak sensor and water sensors can be incorporated together or function together as separate devices, or a highly sensitive water sensor can also function as a leak sensor and then functions to transfer individual water use in different areas of a house and transfer this data and leak alarms to an owner, individual user, corporate responsible individuals, government agencies or municipalities to review water use and water conservation information on a remote device, such as a cell phone, smart phone, or similar apparatus, or to a remote computer. This technology can also be applied to corporations which have various water connected apparatuses that need to be monitored for water flow, water use, and water energy use, and water leaking conditions.

Shown in Figures both **9A** and **9B** is a perspective view of a typical cell phone, smart phone or similar apparatus having a second application (APP), or a second page of a application (APP), programmed to display soft buttons or control activator. FIG. **9** can be a typical cell phone, smart phones, or similar apparatus includes all remote cellular phones using channel access methods defined above (with cellular equipment, public switched telephone network lines, satellite, tower and mesh technology), mobile phones, PDAs, tablets (e.g. refers to all current and future variants, revisions and generations of the Apple IPAD, Samsung Galaxy, HP, Acer, Microsoft, Nook, Google Nexus, Sony, Kindle and all future tablets manufactured by these and other manufactures), Apple IPOD Touch, a smart or internet capable television, wireless timepiece or watch (Apple, Samsung) and other similar apparatus with WIFI and wireless capability, and remote computers and controllers having internet or wireless connectivity. These devices may also be referred to in FIG. **10** as support types and FIG. **11** as remote devices.

The typical cell phone, smart phone or similar apparatus **400** is designed and can also utilized, and show on its display, the example of a first application or page (APP) **300** for Water Use **302** shown in FIG. **8**. The typical cell phone, smart phone or similar apparatus **400** can function at the first remote and/or recorder apparatus **50**, second remote and/or recorder apparatus **56**, and/or communicate under a cellular format technology with offsite central monitoring computer or cell, mobile or other telephone lines via satellite, microwave technology, the internet, cell tower, telephone lines, and the like.

Referring to FIG. **9B** which shows one or more visual signals **409**, **411** (e.g. LED or LCD) lights that are turned on (and off after a period of time) to communicate to an individual that the water use and water energy use monitoring display apparatus base station **10**, **126** has completed the programmed activity. For example only, **409** could be a red LED light that illuminates when the water system is turned off and **411** could be a green LED light that illuminates when the water system is turned on. This could be useful when a water leak alarm is communicated to the typical cell phone, smart phone or similar apparatus **400**. It is anticipated by the Applicant that verbal signal (verbal "water off" or verbal "water on" or simply a playing certain ringtones) can also be used to communicate that the programmed activity has been completed.

Typical cell phones, smart phones, and similar apparatuses **400** may have one or more means of communication that can become established with a particular water use and water energy use monitoring display apparatus base station **10**, **126** for wireless communication. The use of Bluetooth wireless technology **420***a* is commonly a feature found on many cells phones, smart phones and similar apparatus **400**. Such Bluetooth wireless communication **420***a* can be a means to communicate with the water use and water energy use monitoring display apparatus base station **10**, **126** to download water use data and information or communicate with optional water shut-off/on mechanism **310** to turn the water on or off or receive decisional text messages **410**. Zigbee is another wireless technology that can be used. However, most current cell phones, smart phones or similar apparatus **400** do not possess Zigbee wireless capability.

The use of WIFI (IEEE 802.11 family of wireless local area network) wireless technology **420***b* is commonly a feature found on many cells phones, smart phones and similar apparatus **400**. Such WIFI wireless communication **420***b* can be a means to communicate remotely with the water use and water energy use monitoring display apparatus base station **10**, **126** (with optional water shut-off/on mechanism) wirelessly communicate water use and water energy use and water quality) to download water use data and information. The water use and water energy use monitoring display apparatus base station **10**, **126** can have the capability to receive and transfer wireless signals and decisional text messages **410** using WIFI technology directly to the remotely water use and water energy use monitoring display apparatus base station **10**, **126**. Alternately, the WIFI communication **420***b* will communicate with a wireless router that has a HTML based interface and configuration page graphic user interface. Remote access from the cell phone, smart phone or similar apparatus **400** could use a

short message service (SMS) interface and/or voice of Internet Protocol (VOIP) which communicates with the wireless router. This WIFI technology will access the internet and have the ability to recognize the cell phone, smart phone or similar apparatus **400** phone number for remote capability using SMS interface. A digit numbers security can be used to maintain restricted integrity. Wireless Transmitters and Receivers can be used for WIFI communication **420***b* to the remotely water use and water energy use monitoring display apparatus base station **10**, **126** for individuals lacking internet capability at their residence.

The use of cellular wireless technology **420***c* is a primary feature of cells phones, smart phones and similar apparatus. Such cellular wireless communication **420***c* can be a means to communicate with the remotely located water use and water energy use monitoring display apparatus base station **10**, **126** (with optional water shut-off/on mechanism) to transfer water use and water energy use and/or water quality data and information, alarms limits (leaking water situations).

An application (APP) or page **402** will have to interface with the Bluetooth **420***a*, WIFI **420***b*, or cellular **420***c* wireless communication means, and send instructions to a specific "paired" to the water use and water energy use monitoring display apparatus base station **10**, **126**. The water parameter use display and monitoring device **10**, **126** is designed to transfer water use and/or water quality data and information (or alarms) by utilizing the wireless communication with the one or more remote display and/or recorder apparatus, or cell phone, smart phone or similar apparatus **400** whereby the remote display and/or recorder apparatus or cell phone, smart phone or similar apparatus **400** can automatically convert back and forth from radio frequency format, ZigBee or Bluetooth format to a cellular format technology to accommodate different range requirements.

Various pairing methods between the water use and water energy use monitoring display apparatus base station **10**, **126** and the cell phone, smart phone or similar apparatus **400** are contemplated to be necessary to ensure that proper communication is established between a single and unique water use and water energy use monitoring display apparatus base station **10**, **126** in addition to one or more unique cell phone, smart phone or similar apparatus **400**. A Quick Response Code (QR code) unit address located on the water use and water energy use monitoring display apparatus base station **10**, **126** can communicate with a cell phone, smart phone or similar apparatus **400** having a camera to read QR and establish link to the on the water use and water energy use monitoring display apparatus base station **10**, **126**. Standard barcodes could would to pair and establish a link between the water use and water energy use monitoring display apparatus base station **10**, **126** and the cell phone, smart phone or similar apparatus **400**. Near field link and RFID chip technology can also be used to facilitate pairing and establish a link between the water use and water energy use monitoring display apparatus base station **10**, **126** and the cell phone, smart phone or similar apparatus **400**. Currently bar code readers are applications that can be downloaded for a particular cell phone, smart phone or similar apparatus operation system. Near field links are only recently becoming available on Samsung smart phones, but this technology may be expanded to many, if not all, cell phones, smart phones or similar apparatus.

In operation, an individual who wants to turn off the water system would touch the off the soft button **406** or reply to the text message to turn off the water system **410** "yes" soft button **412**, or push the hard button **416***b* on the a cell phone, smart phone or similar apparatus **400** which will communication with the water use and water energy use monitoring display apparatus base station **10**, **126** via the internet, wireless technology (e.g. Bluetooth, ZigBee), and/or cellular format technology and then the paired with the water use and water energy use monitoring display apparatus base station **10**, **126** transmit water use, water energy use (and water quality) data and information (or can turn off the water system off) and then when completed will send a returned communication signal to the a cell phone, smart phone or similar apparatus **400** and turn on signal (audio or visual) message **409** that the data or information has been transferred or that the water system is off. An individual who wants to use the second application (APP), or a second page of an application (APP) **401** to turn on the water system would touch the "on" the soft button **404** or reply to the text message to turn off the water system **410** "no" soft button **412**, or push the hard button **416***a* on the a cell phone, smart phone or similar apparatus **400** which will communication with the water use and water energy use monitoring display apparatus base station **10**, **126** via the internet, wireless technology (e.g. Bluetooth, ZigBee), and/or cellular format technology and then the paired water use and water energy use monitoring display apparatus base station **10**, **126** could download water use date and information or optionally turn off the water system off and then when completed (specified by switches and/or a flow sensor) will send a returned communication signal to the a cell phone, smart phone or similar apparatus **400** and turn on signal (audio or visual) message **409** that the water system is off.

The cell phone, smart phone or similar apparatus can be programmed to utilized geo-fencing technology that uses a radius around a home, corporation, point location or can be a predefined set of boundaries, like school attendance zones or neighborhood boundaries. When a device having geo-fencing technology of a location-based service enters or exits a geo-fence area, the device receives a generated notification of such movement. This notification might contain specific information about the location of the device or simply transfer the location information to a remote apparatus. The device having geo-fencing generally uses GPS (global positional system) for location, determination but with multiple cell towers servicing a cell phone, smart phone or similar apparatus, the multiple cell towers format can utilize triangulation or multi-lateration of radio signals between (several) radio towers of the network and the phone. To locate the phone using multi-lateration of radio signals, it must emit at least one other signal (roaming) to contact the next nearby antenna tower (this location process does not require an active call). GSM cell phone technology is based on the signal strength to nearby antenna masts. The technology of locating is based on measuring power levels and antenna patterns and uses the concept that a powered mobile phone always communicates wirelessly with one of the closest base stations, so knowledge of the location of the base station implies the cell phone is nearby. Advanced systems determine the sector in which the mobile phone resides and roughly estimate also the distance to the base station. Further approximation can be done by interpolating signals between adjacent antenna towers. Qualified services may achieve a precision of down to 50 meters in urban areas where mobile traffic and density of antenna towers is sufficiently high whereas. Rural and desolate areas may see miles between base stations and therefore determine locations is obviously less precise. WiFi data can also be used to identify a cell phone, smart phone or similar apparatus location. Poor performance of the GPS-based methods in

indoor environment and increasing popularity of WiFi have encouraged companies to design new and feasible methods to carry out WiFi-based indoor positioning. Many cell phones, smart phones and similar apparatus combine GPS) with Wi-Fi for both active calling and positioning systems. When a device with geo-fencing technology exist or enters a defined area, a notice might be sent to a cell phone, smart phone or similar apparatus, an email account or perform a or software operation. Geo-fencing allows users of the system to draw zones around places of residence or corporations, customer's sites and secure areas. So a cell phone can be programmed for a defined geo-fence location and can provide a warning to the user or operator via SMS or Email that the water supply is on or provide the user with an option of turning off the water supply.

To ensure that data and information transfer and communication is available at all times and that information or data has integrity that does not alter in any way when the cell phone, smart phone or similar apparatus **400** is not local but is in a remote long range location, and to endure that information or data has been correctly and promptly transferred, a remote service facility can be utilized with the present invention. In FIG. **10** is a block diagram of a method that provides additional integrity technology for the transfer of data. At a home or business customer premises **442**, a modem and router/server **438** connected to a cable, DSL, satellite or other service, e.g. T1 internet connection, that connects with the water use and water energy use monitoring display apparatus base station **200** via wired **446** or wireless means **445**. The broadband modem and router **438** connects to the internet **433** via wired **440** or wireless **441** means and communicate with the governmental agency, insurance company, municipality agencies and/or third party station **470** via an optional wired **466** or wireless **467** means or via an optional wired **466** or wireless **467** means to a remote computer/server service center (cloud) hosted by an insurance, municipality agencies and/or third party monitoring, and data center) with the communications takes place via a communication network **434**, **436** (e.g., cellular network, internet, etc.). The modem router/server **438** can communicate directly with a home owners mobile phone, smart phone, or similar apparatus **400** to the network utilizing communications that takes place via a communication network wired **422** or wireless **423** or cellular network **436**, via the internet to cellular tower network communication **438** and via cellular tower network to mobile phone, smart phone, or similar apparatus **425**. These remote computer/server service centers ("the cloud") **452** manage the system operations necessary to deliver the integrity of the system service described herein. The combination of the modem/router **438** and the remote computer/server service center (cloud) **452** enable a variety of devices **430** (e.g., PCs, mobile phones and PDAs, computers, televisions) to communicate with the water use and water energy use monitoring display apparatus base station **200** and allows users to remotely access water use, water energy use (water quality data) or to control the residential or commercial water supply.

Remote computer/server service centers **452** utilize cloud monitoring tools, specifically, enable cloud providers to track the performance, continuity and security of all of the components that support service delivery: the hardware, software and services in the data center and throughout the network infrastructure. Within the remote computer/server service center **452** are management modules service provisioning and delivery management **454** which takes an end-to-end approach to managing delivery and activation of services in an environment made increasingly complex by third parties, multiple vendors and multiple technologies. The business operation support system **456** utilize software applications that support customer-facing activities such as billing, order management, customer relationship management, call center automation. The operational support system **456** software and hardware applications that support back-office activities which operate a telco's network, provision and maintain customer services. Both support systems **456** are traditionally used by network planners, service designers, operations, architects, support, and engineering teams in the service provider. These software programs and hardware use web services **464** such as XML, APIs and token authentication technology.

The integrated insurance, municipality agency or other third party service **470** can also coordinate the monitoring of compliance data use and/or perform the services of the Remote Operational Service Centers **452** and the optional communication with the internet **434**.

In addition to standard HTTP or HTTPS communications, the modem and router/server **438** and remote computer/server service center **438** can support the use of a cellular network **436** (both GPRS, GSM and CDMA options are available) as another means to provide the primary broadband connection **438** to the internet **434**. Routers/servers such as those currently seen in homes or companies are enabled to communicate with the internet via a DSL line (over the standard switch telephone network or cable modem. One viable option is to build a cellular network circuitry into the broadband router or remote base station. As one example of the internet of things technology, Particle Inc. in California manufactures a microprocessor/microcontroller called the Electron that includes a SIM car and a unique cellular service. Alternately, a smart phone can be used as a "hotspot". When configured as such, the smart phone ("hotspot" turns instantly into a broadband router to which the remotely communicates with the water use and water energy use monitoring display apparatus base station **200** (not shown).

FIG. **11** is a block diagram of components of the present invention, under an embodiment, showing a more detailed description of the components. The diverse collection of apparatus/devices **480** range from computer **482**, PC applications or programs **484**, or touch screen keypads, mobile devices **486**, email **488**, hub **490** or wireless (GPRS, GSM or CDMA) or internet connected televisions **492**.

The apparatus/devices **480** accessing a web portal application **496** through the internet **434**, which performs an end-user configuration and customization of the integrated service. In addition, device management is capable of performed by the mobile portal application **500**. A mobile device **486** (e.g., PDA, mobile phone, etc.) accessing the integrated system Mobile Portal **500**.

There are numerous types of server components of the Remote Operation Data Service Center **452**. Business Components which manage information about the controlling/monitoring devices, using Web 2.0, and XML APIs (see FIG. **10**). Within the OSS/BSS Components are the Customer Help Desk **502** which provides information about remote devices and base station installment instructions and operation and technology questions. The Service Delivery and Management Application **504** enables operators to administer the service (these components also access the Business Components via the XML APIs, and also via published SNMP MIBs). Service provisioning **506** can be used to include a 3^{rd} party to monitor leak flow sensors located at a residence or company and provide alarms or send messages

to the client when water leak problems are detected. If the residence or company hires a 3rd party or has account with a 3rd party, an insurance company and/or municipality agencies, the Order, Management and Billing Component **508** will manage this service.

The server components provide access, and management of, the objects associated with an integrated broad. It is a location where modem/router **438** and the water use and water energy use monitoring display apparatus base station **200** is located in a home or company, and is also commonly referred to as a site or premises; the site or premises can include any type of structure (e.g., home, office, warehouse, etc.) at which a modem/router **438** and the water use and water energy use monitoring display apparatus base station **200** are located. Remote devices can only access the networks to which they have been granted permission through activation (e.g. pairing process).

The low-level service management activities for the integrated system service. They define all of the remote devices, for example, the cell phone, smart phone or similar apparatus **400**, computer browser, PC applications or programs or TV (with internet capability), associated with residential or corporate premise network, analyze how the devices interact, and trigger associated actions (such as sending signals to turn on or off the water system, or provide notifications to home or company owners). All changes in device states are monitored and logged for subsequent evaluation. The business components also manage all interactions with external systems as required, including sending alarms and other related self-monitoring data to the owners or the optional insurance, municipality agency or a third party monitoring station. The following Operational Support Systems (OSS) and Business Support Systems (BSS) various components manage the main elements of the integrated security system service, but the embodiment is not so limited: A Registry Manager **526** defines and manages remote devices and networks. This component is responsible for the creation, modification and termination of devices and networks. A Network Manager **524** defines and manages security and self-monitoring devices that are deployed on a network (site). This component handles the creation, modification, deletion and configuration of the devices, as well as the creation of automations, schedules and notification rules associated with those devices. An element management system **522** manages one or more of a specific type of telecommunication network elements. A Data Manager **530** manages access to current and historical state data for an existing network and its devices. This component specifically does not provide any access to network management capabilities, such as adding new devices to a network, which are handled exclusively by the Network Manager **524**. To achieve optimal performance for all types of queries, data for current device states is stored separately from, but linked together, in the historical activity data (a.k.a. "logs") in the database.

Additional operational support system and business support systems direct and manage communications with certain remote devices and systems. For example, Hub Manager **530** directly manages all communications with the remotely located water use and water energy use monitoring display apparatus base station **200** and the remote devices **480** receiving information about device state changes, changing the configuration of devices, and downloading new versions or software updates to the remotely located water use and water energy use monitoring display apparatus base station **200** and/or remote devices **480** hardware. A Notification Manager **528** is responsible for sending all notifications to clients via SMS (mobile phone messages), email (via a relay server like an SMTP email server), etc. The Element Management System **522** is a Business Component that manages all activities associated with service installation, scaling and monitoring, and filters and packages service operations data for use by the service management applications.

The OSS/BSS store information about the devices that they manage in the one or more databases **536**. The one or more databases **536** store information about users, networks, devices and logged activities. This database interaction is performed via an appropriate interface. For security purposes, the various OSS/BSS components manage all data storage and retrieval. The various OSS/BSS components provide web services-based APIs that provided communication routes application components use to access the various other OSS/BSS components. Business Components' capabilities. Functions of application components include presenting integrated security system service data to end-users, performing administrative duties, and integrating with external systems and back-office applications.

API (application program interface) is a set of routines, protocols, and tools for building software applications. The API specifies how software components should interact and APIs are used when programming graphical user interface (GUI) components. A good API makes it easier to develop a program by providing all the building blocks. The primary functions of the data, network and registry APIs for the OSS/BSS components include, but are not limited to, the following: A registry API **518** provides access to the various software components and hardware allowing management of networks and devices. A network API **518** provides access to the various software and hardware components, allowing management of devices on a network. A data API **518** provides access to the various software and hardware components, such as setting and retrieving (current and historical) data about device states. A provisioning API **516** provides a convenient way to create new networks and configure initial default properties.

Each API of an embodiment includes two modes of access: Java API or XML API. The XML APIs are published as web services so that they can be easily accessed by applications or servers over a network. The Java APIs are a programmer-friendly wrapper for the XML APIs. Application components and integrations written in Java should generally use the Java APIs rather than the XML APIs directly.

The OSS/BSS components also have an XML-based device connect interface **534** for quickly adding support for new devices to the integrated security system. This interface **534** is a flexible, standards-based mechanism for defining the properties of new devices and how they can be managed. Although the format is flexible enough to allow the addition of any type of future device, pre-defined XML profiles are currently available for adding common types of devices such as new sensors **540** (e.g. water quality sensor).

Once a user sets up a service, an Activation Application Application **494** delivers a first display to the user on either a display mean on the water use and water energy use monitoring display apparatus base station **200** and/or on a display means on the remote devices **480**. This pairing technology or other application secure means associates a user with a remote device **480** and the remotely water use and water energy use monitoring display apparatus base station **200**. It primarily uses functionality published by the Provisioning API. Alternately, a web portal application **496** can run on PC and cell phone browsers and delivers the

web-based interface to the integrated system devices. This application allows users to manage their networks (e.g. add devices and create automations) as well as to view/change device states. Because of the wide scope of capabilities of this application, it uses three different Business Component APIs that include the Registry Manager API, Network Manager API, and Data Manager API **518**. A Mobile Portal **500** is a small-footprint web-based interface that runs on cell phones, mobile phones and similar apparatuses. Potentially, the interaction with the Business Components is primarily via the Data Manager API. Custom portals and targeted client applications can be provided leveraging the same Business Component APIs used by the above applications. A Content Manager Application Component **498** delivers content to a variety of users. It sends multimedia type user interface components to widget container clients (both PC and browser-based), as well as to advanced touch screen keypad clients.

A number of application components ensure overall management of the OSS/BSS service. These applications, referred to as Service Management Application Components **512**, are configured to offer off-the-shelf solutions for production management of the integrated security system service including provisioning, overall service monitoring, customer support, and reporting, for example. The Service Management Application **512** allows service administrators to perform activities associated with service installation, scaling and monitoring/alerting. This application interacts heavily with the Element Management System **522** Business Component to execute its functionality, and also retrieves its monitoring data from that component via protocols. The CSR APP and Report Generator **510** is useful for provide reports in specific format for residential home owners and user, company owner and users, and/or the insurance company or a municipality agency. A Kitting Application **514** is used by employees performing service provisioning tasks. A Customer Help Desk **502** can be incorporated into the system to provide FAQs, service and maintenance calls. Service Delivery and Management **504** refers to the installing and management of the remote controllable base stations **200** at various residences and corporations. The Service Provisioning module **506** refers to the scheduling of maintenance of communication equipment and remote controllable base stations **200**. The Order, Management and Billing module **508** relates to those services provided and management of services, such as monthly reports, surveillance programs, account receivables and well business costs, assets, liabilities and capital expenditures.

FIG. **12** is a block diagram including base station software or applications. The base station software architecture has relatively small programmed instructions that are efficient, thereby simplifying its integration into other consumer appliances such as service routers. The software architecture also provides a high degree of security against unauthorized access. This section describes the various key components of the base station software architecture.

The control software includes a remote computer application layer **580** which is the main program that orchestrates the operations the mobile phone, smart phone or similar apparatus connection software **582**, the modem/router connection **584** and the optional base LED/LCD panel connections. The Security Engine **588** provides robust protection against intentional and unintentional intrusion into the integrated water use and water energy use monitoring display and remotely controllable base station **200** (**10**, **126**) both from inside the premises as well as from the WAN, LAN or Internet or outside premises). The Security Engine **588** comprises one or more sub-modules or components that perform functions including, but not limited to, the following: Encryption including the evolving secure socket layer (SSL) encryption to provide secure communication. Bi-directional authentication between the water use and water energy use monitoring display and remotely controllable base station **200** (**10**, **126**) and the remote mobile phone, smart phone or similar apparatus **480** is used to confirm that the soft ware instructs have been completed. Data sent from the modem/router server **438** to the remote mobile phone, smart phone or similar apparatus **480** (or vice versa) is digitally signed as an additional layer of security. Non-repudiation technology that prevents a sender from denying that a message, data or information was sent can be incorporated to prevent fraudulent activities. Digital signing provides both authentication and validation that the data has not been altered in transit. The modem/router **438** provides for SSL encapsulation of signal data sent over the internet **434** for complete integrity. Wireless IEEE 802.11b/g/n/x with WEP, WPA-PSK [TKIP], WPA2-PSK [AES], WPA-PSK [TKIP]+WPA2-PSK [AES] or other security protocol variant to ensure that signals and communications always takes place using the strongest available protection. Attempts to activate gateway-enabled devices by intentional and unintentional intrusion are detected by the Security Engine. Pairing remote devices **480** have the information with the correct serial number or activation key (pairing) can be activated for use with the water use and water energy use monitoring display and remotely controllable base station **200** (**10**, **126**).

As standards evolve, and new encryption and authentication methods are proven to be useful, and older mechanisms proven to be breakable, the remote mobile phone, smart phone or similar apparatus **480** and the water use and water energy use monitoring display and remotely controllable base station **200** (**10**, **126**), or components of the OSS/BSS can be upgraded by downloading updated software wirelessly or by a physically means of swapping out electrical components to provide new and better security for communications between the remote mobile phone, smart phone or similar apparatus **480** and the water use and water energy use monitoring display and remotely controllable base station **200** (**10**, **126**).

A firmware download module **590** allows for secure updates to the modem/router **438** or remote device firmware through the Device Management Application **594** providing a transparent hassle-free mechanism for the service provider to deploy new features and bug fixes to the installed user base. The firmware download mechanism **590** is tolerant of connection loss, power interruption and user interventions (both intentional and unintentional). Such robustness reduces down time and customer support issues.

The schedules/automation engine **582** manages the user-defined rules of interaction between the different devices and for executing the user defined schedules of the off/on water system schedules.

Device connection software **582** includes definitions of all supported devices (e.g., key chains, mobile phone, smart phone or similar apparatus **400**, water sensors, etc.) using a standardized plug-in architecture. The device connection module **582** offers an interface that can be used to quickly add support for any new device as well as enabling interoperability between devices that use different technologies/protocols. For common device types, pre-defined sub-modules have been defined, making supporting new devices of these types even easier.

The device management module **594** is in charge of all discovery, installation and configuration of both wired and wireless IP devices coupled or connected to the system. Networked IP devices require user configuration of many IP and security parameters to management module of an embodiment handles the details of this configuration.

The Operating Software **596** can be any variety of operating systems such as Linux, Windows, Apples OS or other programs. The advantage of an operating system is its ability to conduct multi-tasking operations that allows more than one program to be running in concurrency. The Standard software thus can function to cooperate with the control software, the hardware layer, USB systems **598**, serial data ports **600**, TCP/IP protocols **602**, WiFi 802.11 b/g/n/x/y and/or Ethernet ports. The Hardware layer includes mass storage discs **608**, CDMA/GSM cellular circuitry **610**, RF WiFi circuitry **612**, WAN **614**, touchscreen technology **616**, BlueTooth circuitry **618**, ZigBee and other wireless technology **620**.

The system and method of the present invention provide an automated system that can reliably identify and report the status of flow through water fixtures found in various rooms, area, and/or facilities. In a real time, the identification of leaks can be brought to the attention of an owner or appropriate repair individual thereby offsetting costs of system implementation of the present invention by savings in water costs and benefits in water conservation.

While this invention has been described as having a preferred design, the present invention can be further modified within the spirit and scope of this disclosure. The application is therefore intended to cover any variations, uses, or adaptations of the invention using its general principles. Further, this application is intended to cover such departures from the present disclosure as come within known or customary practice and the art to which this invention pertains and which fall within the limits of the appended claims.

The invention claimed is:

1. A water use monitoring and leak detection apparatus comprising:

a base station apparatus designed to be connected to a main water supply means;

said base station includes a joint means for connecting to a cold/ambient water supply, or a joint means for connecting to a cold/ambient water supply and a joint means for connecting to a hot water supply, said base station have a joint means for connecting to outgoing water supply line(s) for a home residence, company or building structure;

electrical circuitry including one or more microprocessors or microcontrollers with a power source contained with said base station apparatus;

said power source is either AC powered, DC powered, or powered with one or more batteries, said power source is electrically connected to said electrical circuitry;

one or more flow sensors in communication with a water supply, said one or more flow sensors in electrical communication with said electrical circuitry;

one or more wired or wireless electrical communication means, said wired or wireless electrical communication means having the capability to transfer water parameter, water energy and/or water quality information or data to one or more remote apparatuses, said wired or wireless electrical communication means utilizes protection technology to securely provide water use, water energy and/or water quality information and/or data in a confidential format;

said base station includes mesh-enabled circuitry that can communicate with other base stations for transferring water flow, water energy and/or water quality data;

said base station(s) functioning as one or more access points that transfer said water flow, water energy and/or water quality data, using encryption and identification technology to an internet connection;

said water flow, water energy and/or water quality data transferred over the internet connection to one or more remote computers or computer servers, and;

said remote computers or servers allow registered owners and users to access their registered water flow, water energy and/or water quality data using a cell phone, smart phone, mobile phone, or a mobile electronic communication device.

2. A water use monitoring and leak detection apparatus comprising:

a base station in close proximity to a main water supply;

said base station includes a joint means for connecting to a cold/ambient water supply, or a joint means for connecting to a cold/ambient water supply and a joint means for connecting to a hot water supply, said base station have a joint means for connecting to outgoing water supply line(s) for a home residence, company or building structure;

said base station further comprising a first power supply, said first power supply is either AC powered, DC powered, or powered with one or more batteries, said first power supply electrically connected to a first circuitry which has one or more microprocessors or microcontrollers;

one or more water flow sensors in communication with a water supply, said one or more water flow sensors in electrical connection with a first electrical circuitry;

said base station monitors and processes water parameter data including water flow, water energy, and/or water quality data;

said base station includes software that controls and sequences the water parameter data and prepares said data for wired or wireless transfer;

a receiving station, said receiving station having a second electrical circuitry including one or more second microprocessors, said receiving station remotely located from said base station;

said receiving station having a second power supply, said second power supply is either AC power, DC power, or powered with one or more batteries, said second power supply electrically connected to a second circuitry;

said first electrical circuitry of said base station is in wire or wireless communication with said second electrical circuity of said receiving station;

said receiving station designed to establish Wi-Fi, Bluetooth or ZigBee electrical communication with a wireless router/server, and/or cellular communication with a cell tower technology, and any combinations thereof;

said receiving station includes mesh-enabled circuitry that can communicate with other receiving stations for transferring water flow, water energy and/or water quality data to one or more access points;

said receiving station or a custom transfer apparatus functioning as one or more access points for transferring said water flow, water energy and/or water quality data over an internet connection to one or more remote computers or computer servers; and

said computer servers allow registered owners and users to access their registered water flow, water energy

and/or water quality data using a cell phone, smart phone, mobile phone or a mobile electronic communication device.

3. The water use monitoring and leak detection apparatus of claim 1, wherein said cell phone, smart phones, mobile phones, mobile electronic communication device such as PDAs, tablets (refers to all current and variants, revisions and generations of the APPLE®, SAMSUNG®, HP®, ACER®, MICROSOFT®, NOOK®, GOOGLE®, SONY®, KINDLE® and other tablets manufactured by these and other manufactures), APPLE TOUCH®, a smart or internet capable television, wireless timepiece or wireless watch and other electronic apparatuses with Wi-Fi and wireless capability, and remote computers and controllers having internet, wireless cell format technology connectivity utilizing cellular, Wi-Fi, ZigBee and/or Bluetooth, and any combinations thereof, to communication with the remote cellular phones (with cellular equipment, public switched telephone network lines, satellite, microwave, tower and mesh technology.

4. The water use monitoring and leak detection apparatus of claim 2, wherein said cell phone, smart phones, mobile phones, mobile electronic communication device such as PDAs, tablets (refers to all current and variants, revisions and generations of the APPLE®, SAMSUNG®, HP®, ACER®, MICROSOFT®, NOOK®, GOOGLE®, SONY®, KINDLE® and other tablets manufactured by these and other manufactures), APPLE TOUCH®, a smart or internet capable television, wireless timepiece or wireless watch and other electronic apparatuses with Wi-Fi and wireless capability, and remote computers and controllers having internet, wireless cell format technology connectivity utilizing cellular, Wi-Fi, ZigBee and/or Bluetooth, and any combinations thereof, to communication with the remote cellular phones (with cellular equipment, public switched telephone network lines, satellite, microwave, tower and mesh technology.

5. The water use monitoring and leak detection apparatus of claim 1, further comprising said base station including an electronic water control valve wherein said base station is programmed to automatically turns off the main water supply when a leak is detected or alternately can send an alert signal when a leak is detected to said cell phone, smart phone, mobile phone, or other mobile electronic communication device wherein a user is provided an election to send a command to the base station to control the electronic water control valve to turn off or leave on the main water supply.

6. The water use monitoring and leak detection apparatus of claim 1, wherein said one or more water flow sensors includes independent flow sensors for the main water supply, an irrigation water supply, one or more showers, one or more hot water heaters, one or more washing machines, one or more dishwashers, one or more kitchen faucets, one or more bathroom faucets, one or more toilets, one or more refrigerator water dispenser or ice maker, a Jacuzzi water supply, a pool water supply, and/or a fountain water supply, any other water use device, or any combinations thereof.

7. The water use monitoring and leak detection apparatus of claim 1, further comprising a water use calibration mode for learning the patterns and signature of water use devices within a home, corporation, building or structure.

8. The water use monitoring and leak detection apparatus of claim 1, further comprising automatic learning mode whereby learning software privately tracks an owner's water flow and volume use for a period, assigning water patterns and water signatures to each specific water use device.

9. The water use monitoring and leak detection apparatus of claim 2, further comprising a water use calibration mode for learning the patterns and signature of water use devices within a home, corporation, building or structure.

10. The water use monitoring and leak detection apparatus of claim 2, further comprising automatic learning mode whereby learning software privately tracks an owner's water flow and volume use for a period, assigning water patterns and water signatures to each specific water use device.

11. The water use monitoring and leak detection apparatus of claim 1, wherein said cell phone, smart phones, or mobile phone, or other mobile electronic communication device utilizes geo-fencing technology to provide an owner or user information that they have traveled beyond the defined geo-fence territory and provides the owner or user the option to turn on and off the main water supply.

12. The water use monitoring and leak detection apparatus of claim 1, further comprising a water control means or a variable water flow means, said water control means or variable water flow means controlled by programming instructions from said microprocessor or microcontroller for turning on and off said water control means or setting a variable water flow means, said water control means or variable water flow means can be activated by an owner's or user's cell phone, smart phones, mobile phone, or other mobile electronic communication device, or by a remote apparatus or computer or alternately activated by said one or more wireless or wired means controlled by a municipality or governmental agency.

13. The water use monitoring and leak detection apparatus of claim 2, wherein said cell phone, smart phones, mobile phone, or other mobile electronic communication device utilizes geo-fencing technology to provide an owner or user information that they have traveled beyond the defined geo-fence territory and provides the owner or user the option to turn on and off the main water supply.

14. The water use monitoring and leak detection apparatus of claim 2, further comprising a water shut control means or a variable water flow means, said water control means or variable water flow means controlled by programming instructions from said microprocessor or microcontroller for turning on and off said water control means or setting a variable water flow means, said water control means or variable water flow means can be activated by an owner's or user's cell phone, smart phones, mobile phone, or other mobile electronic communication device, or by a remote apparatus or computer or alternately activated by said one or more wireless or wired means controlled by a municipality or governmental agency.

15. The water use monitoring and leak detection apparatus of claim 1, wherein the transfer of water use, water energy, and/or water quality can "piggy back" on smart electric and/or gas data transfer protocols whereby a third wireless means has the capability to "piggy back" or be designed to be incorporated into and/or cooperation with electric and gas smart meters communication/transmission mesh technology.

16. The water use monitoring and leak detection apparatus of claim 3, wherein said cell phone, smart phones, mobile phone, or other mobile electronic communication device with wireless communication can automatically convert back and forth from radio frequency format, ZigBee or Bluetooth format to a cellular format technology to accommodate range requirements.

17. The water use monitoring and leak detection apparatus of claim 1, wherein the base station can be incorporated into or serve as the pressure regulator or primary water meter at a residential home or commercial facility.

18. The water use monitoring and leak detection apparatus of claim 2, wherein the transfer of water use, water energy,

and/or water quality can "piggy back" on smart electric and/or gas data transfer protocols whereby a third wireless means has the capability to piggy back" or be designed to be incorporated into and/or cooperation with electric and gas smart meters communication/transmission mesh technology.

19. The water use monitoring and leak detection apparatus of claim **2**, wherein the base station can be incorporated into or serve as the pressure regulator or primary water meter at a residential home or commercial facility.

20. The water use monitoring and leak detection apparatus of claim **1**, further comprising a water flow generation apparatus that can be utilized with rechargeable batteries, said rechargeable batteries being supplemented with electrical energy generated by a turbine or other water flow type electrical generation means in hydraulic connection with said water supply source for powering the base unit.

21. The water use monitoring and leak detection apparatus of claim **1**, wherein a single flow rate sensor monitors and detects the source use for one or more main water supply, one or more irrigation system, one or more showers, one or more hot water heaters, one or more washing machines, one or more dishwashers, one or more kitchen faucets, one or more bathroom faucets, one or more toilets, one or more refrigerators with water dispenser and ice making supply lines, one or more Jacuzzi(s), one or more pool water supplies, and/or one or more fountain water supplies, any other water use device, or any combinations thereof, the base station software recording a unique water pattern or water signature for each water use device.

22. The water use monitoring and leak detection apparatus of claim **1**, wherein said monitoring and water source detection can be displayed in a line, graphical or other format one or more wireless or wired remote apparatuses comprises a typical cell phone, smart phones, mobile phone, or other mobile electronic communication device.

23. The water use monitoring and leak detection apparatus of claim **2**, further comprising said base station including an electronic water control valve wherein said base station is programmed to automatically turns off the main water supply when a leak is detected or alternately can send an alert signal when a leak is detected to a said cell phone, smart phone, mobile phone, or other mobile electronic communication device whereby a user is provided an election to send a command to the base station to control the electronic water control valve to turn off or leave on the main water supply.

24. The water use monitoring and leak detection apparatus of claim **2**, wherein said one or more water flow sensors includes independent flow sensors for the main water supply, an irrigation water supply, one or more showers, one or more hot water heaters, one or more washing machines, one or more dishwashers, one or more kitchen faucets, one or more bathroom faucets, one or more toilets, one or more refrigerator water dispenser or ice maker, a Jacuzzi water supply, a pool water supply, and/or a fountain water supply, any other water use device, or any combinations thereof.

25. The water use monitoring and leak detection apparatus of claim **2**, further comprising a water flow generation apparatus that can be utilized with rechargeable batteries, said rechargeable batteries being supplemented with electrical energy generated by a turbine or other water flow type electrical generation means in hydraulic connection with said water supply source for powering the base unit.

26. The water use monitoring and leak detection apparatus of claim **2**, wherein a single flow sensor monitors and detects the source use for one or more main water supply, one or more irrigation system, one or more showers, one or more hot water heaters, one or more washing machines, one or more dishwashers, one or more kitchen faucets, one or more bathroom faucets, one or more toilets, one or more refrigerators with water dispenser and ice making supply lines, one or more Jacuzzi(s), one or more pool water supplies, and/or one or more fountain water supplies, any other water use device, or any combinations thereof, the base station software recording a unique water pattern or water signature for each water use device.

27. The water use monitoring and leak detection apparatus of claim **2**, wherein said monitoring and water source detection can be displayed in a line, graphical or other format one or more wireless or wired remote apparatuses comprises a typical cell phone, smart phones, mobile phone or other mobile electronic communication device.

28. The water use monitoring apparatus of claim **1**, further compromising one or more pressure sensors, said one or more pressure sensors in electrical connection with said first electrical circuitry.

29. The water use monitoring and leak detection apparatus of claim **1**, further compromising one or more temperature sensors, said one or more temperature sensors in electrical connection with said first electrical circuitry.

30. The water use monitoring and leak detection apparatus of claim **1**, further compromising one or more acoustic/sound monitoring sensors, said one or more acoustic/sound monitoring sensors in electrical connection with said first electrical circuitry.

31. The water use monitoring and leak detection apparatus of claim **2**, further comprising one or more pressure sensors, said one or more pressure sensors in electrical connection with said first electrical circuitry.

32. The water use monitoring and leak detection apparatus of claim **2**, further comprising one or more temperature sensors, said one or more temperature sensors in electrical connection with said first electrical circuitry.

33. The water use monitoring and leak detection apparatus of claim **2**, further comprising one or more acoustic/sound monitoring sensors, said one or more acoustic/sound monitoring sensors in electrical connection with said first electrical circuitry.

34. The water use monitoring and leak detection apparatus of claim **4**, wherein said cell phone, smart phones, mobile phone or other mobile electronic communication device with wireless communication can automatically convert back and forth from radio frequency format, ZigBee or Bluetooth format to a cellular format technology to accommodate range requirements.

* * * * *

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(54) **WATER MANAGEMENT SYSTEM**

(76) Inventor: **Saju Anthony Palayur**, San Diego, CA (US)

Correspondence Address:
GEORGE S. LEVY
3980 DEL MAR MEADOWS
SAN DIEGO, CA 92130 (US)

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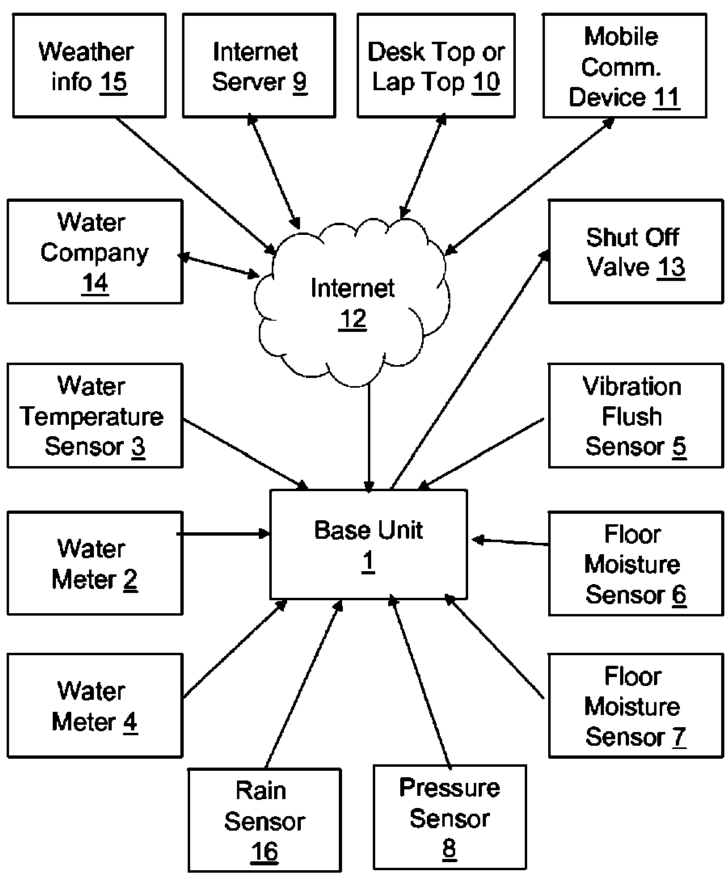
G01F 1/00	(2006.01)
G01R 21/00	(2006.01)
G06F 19/00	(2011.01)
G08B 21/00	(2006.01)

(52) **U.S. Cl.** **700/283**; 705/413; 700/282; 702/45; 702/60; 340/626

(57) **ABSTRACT**

This invention is a water consumption monitoring and control system comprised of a base unit, itself comprising a display and a data entry device, a microprocessor, a communication link to water meters, pressure sensors, temperature sensors, flush toilet vibration sensors and shut-off valves. In addition the base unit has access to the Internet and can access a server which holds a database of water conservation information. This database includes watering advisories from the local government, and weather information from the weather office. The server runs an algorithm and generates control data which is sent to the base unit.



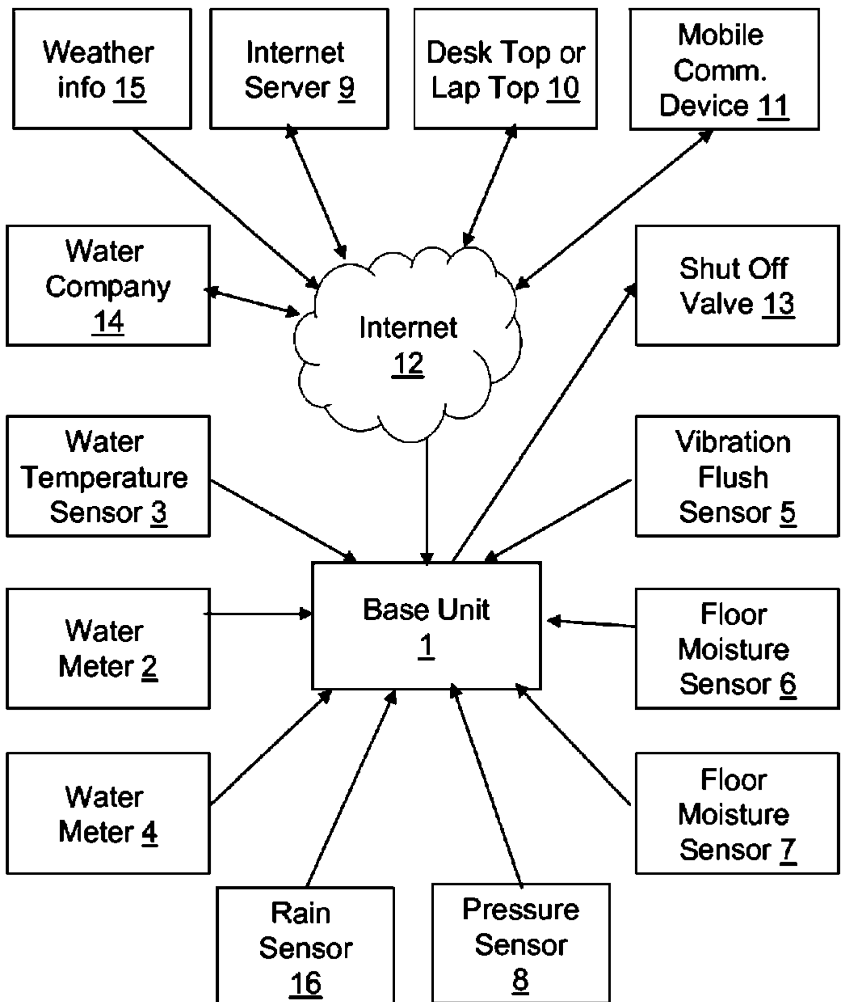

Weather info 15
Internet Server 9
Desk Top or Lap Top 10
Mobile Comm. Device 11
Water Company 14
Internet 12
Shut Off Valve 13
Water Temperature Sensor 3
Vibration Flush Sensor 5
Base Unit 1
Water Meter 2
Floor Moisture Sensor 6
Water Meter 4
Floor Moisture Sensor 7
Rain Sensor 16
Pressure Sensor 8

FIG. 1

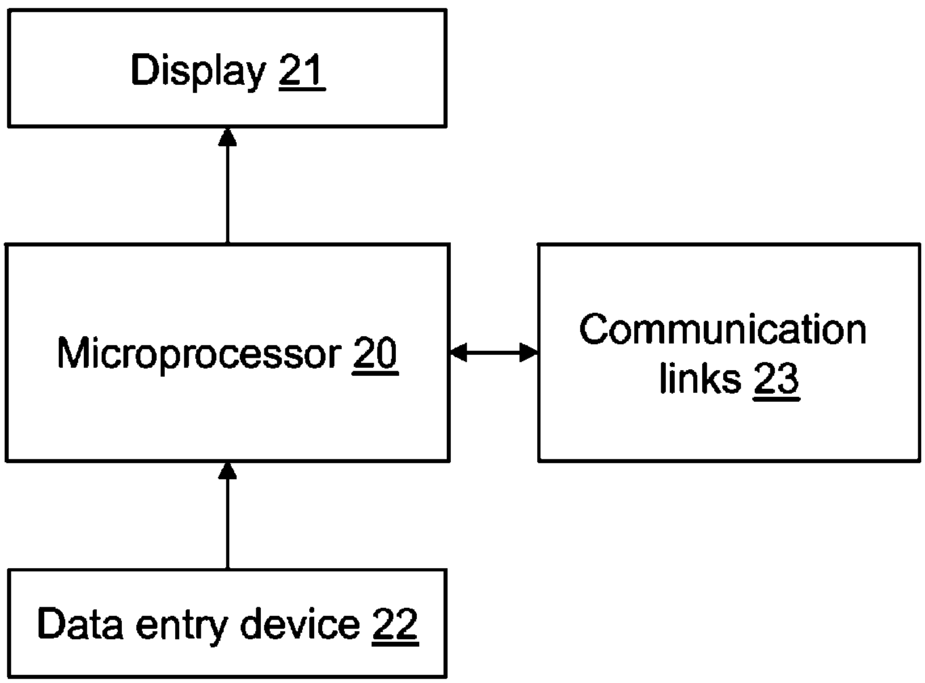

Display 21
Microprocessor 20
Communication links 23
Data entry device 22

FIG. 2

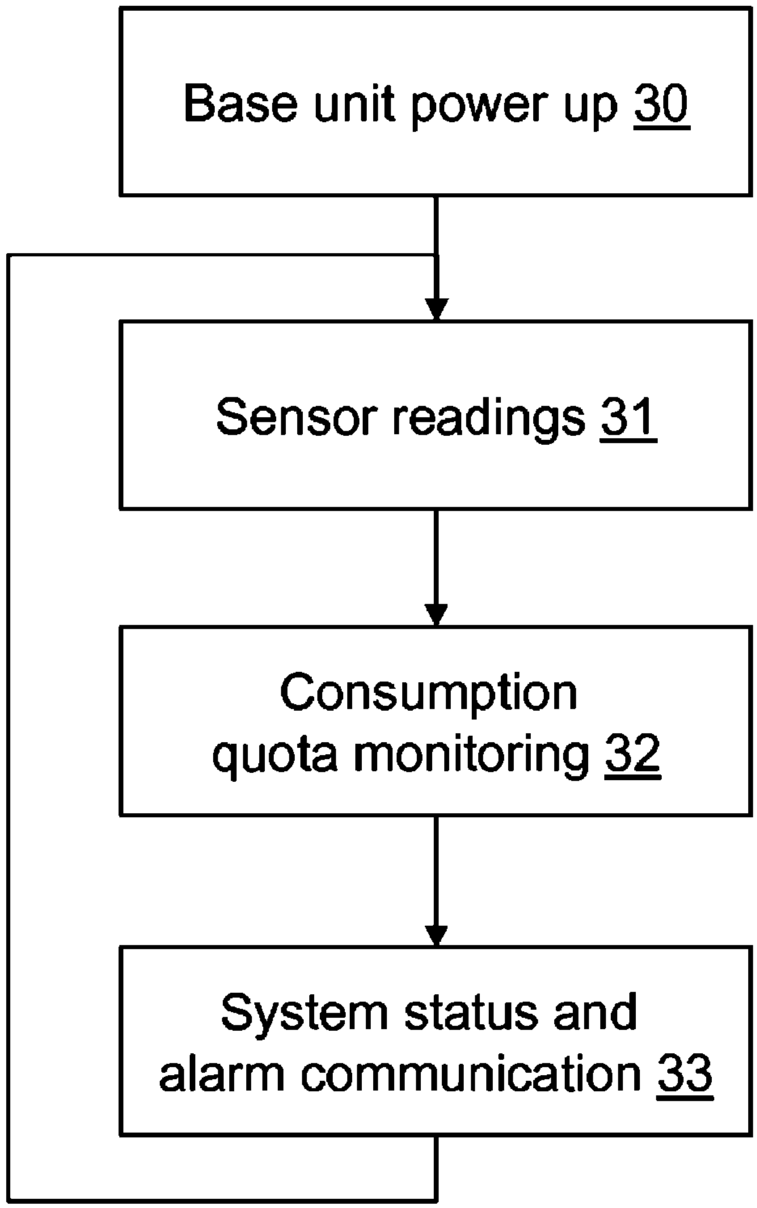

Base unit power up 30
Sensor readings 31
Consumption quota monitoring 32
System status and alarm communication 33

FIG. 3

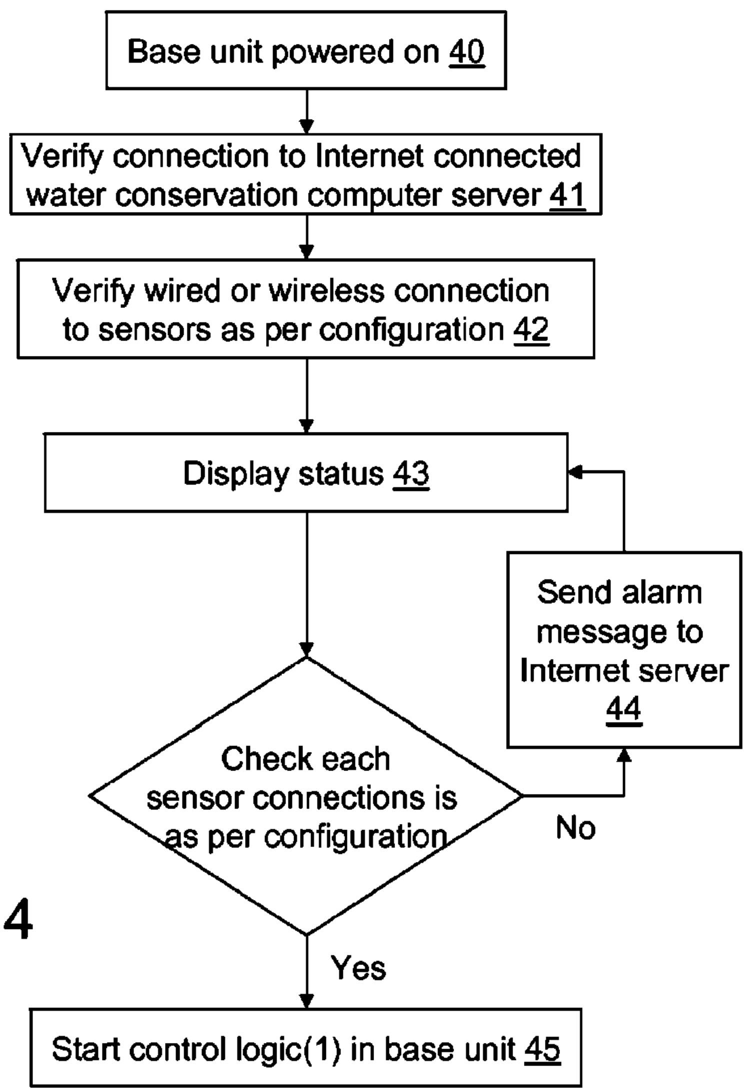

Base unit powered on 40
Verify connection to Internet connected water conservation computer server 41
Verify wired or wireless connection to sensors as per configuration 42
Display status 43
Send alarm message to Internet server 44
Check each sensor connections is as per configuration
No
Yes
Start control logic(1) in base unit 45

FIG. 4

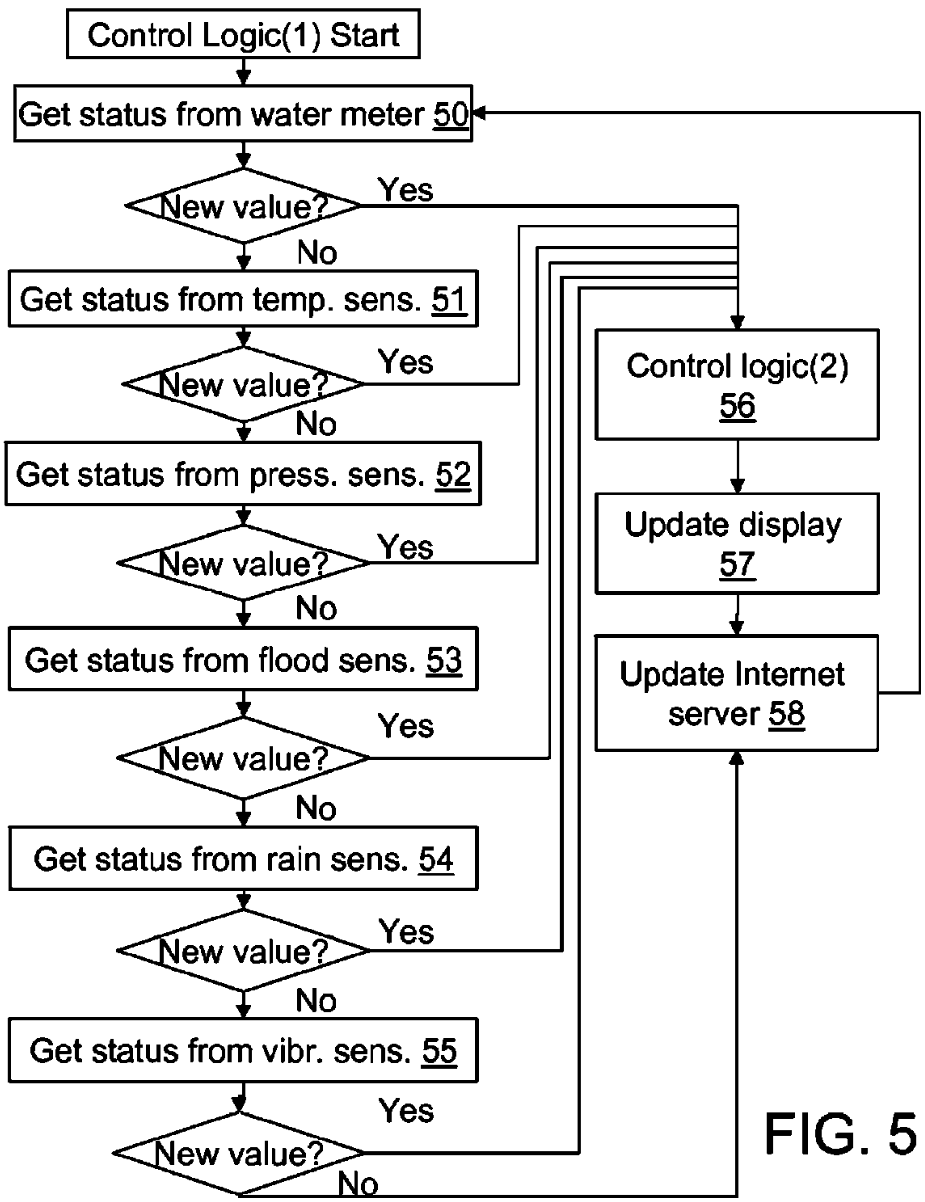
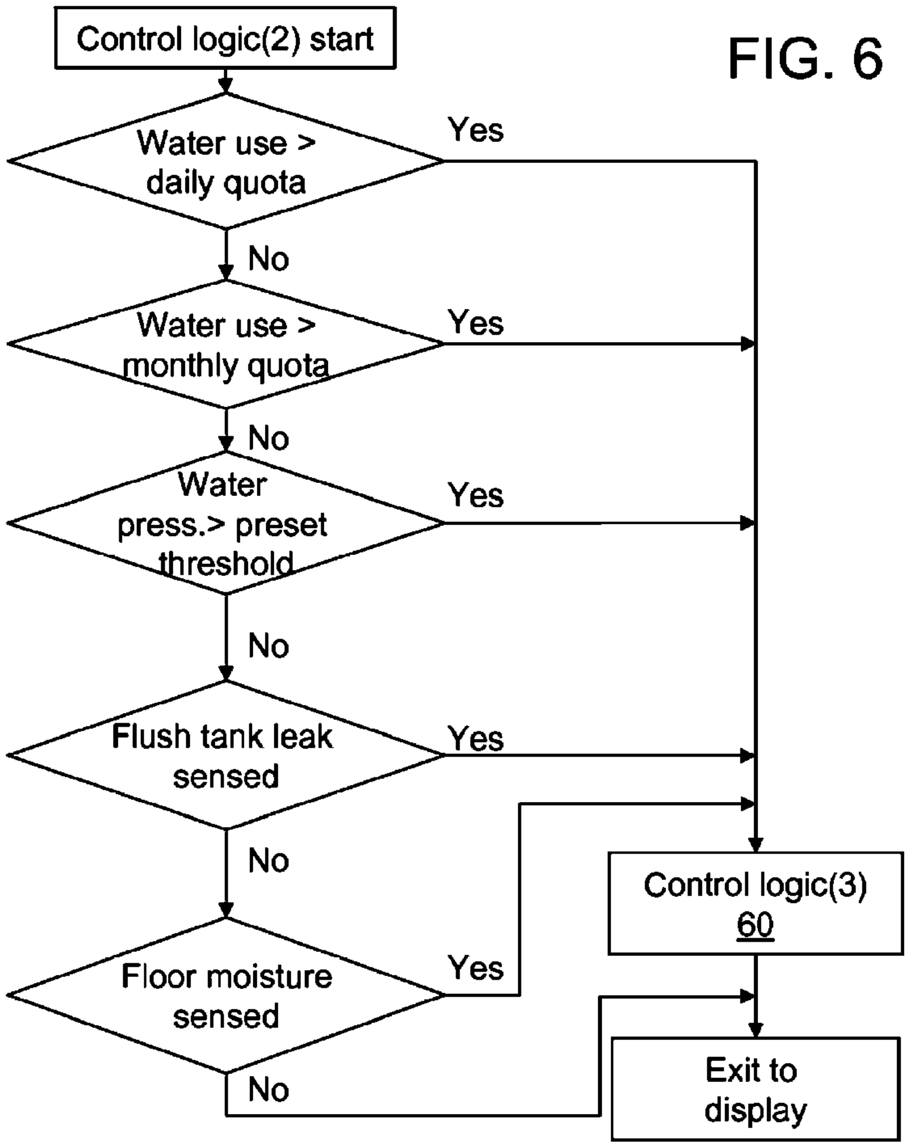

Control Logic(1) Start
Get status from water meter 50
New value?
Yes
No
Get status from temp. sens. 51
New value?
Yes
No
Get status from press. sens. 52
New value?
Yes
No
Get status from flood sens. 53
New value?
Yes
No
Get status from rain sens. 54
New value?
Yes
No
Get status from vibr. sens. 55
New value?
Yes
No
Control logic(2) 56
Update display 57
Update Internet server 58

FIG. 5

FIG. 6


Control logic(2) start
Water use > daily quota
Yes
No
Water use > monthly quota
Yes
No
Water press.> preset threshold
Yes
No
Flush tank leak sensed
Yes
No
Floor moisture sensed
Yes
No
Control logic(3) 60
Exit to display

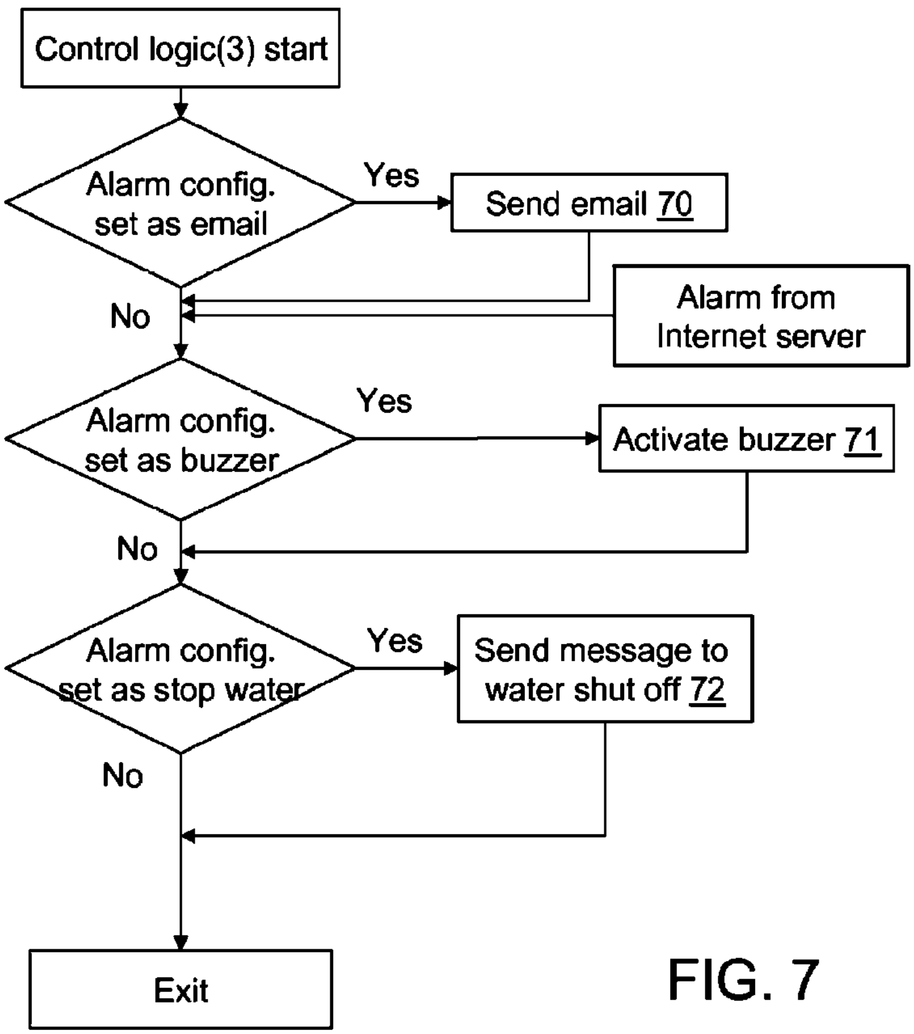

Control logic(3) start
Alarm config. set as email
Yes
Send email 70
No
Alarm from Internet server
Alarm config. set as buzzer
Yes
Activate buzzer 71
No
Alarm config. set as stop water
Yes
Send message to water shut off 72
No
Exit

FIG. 7

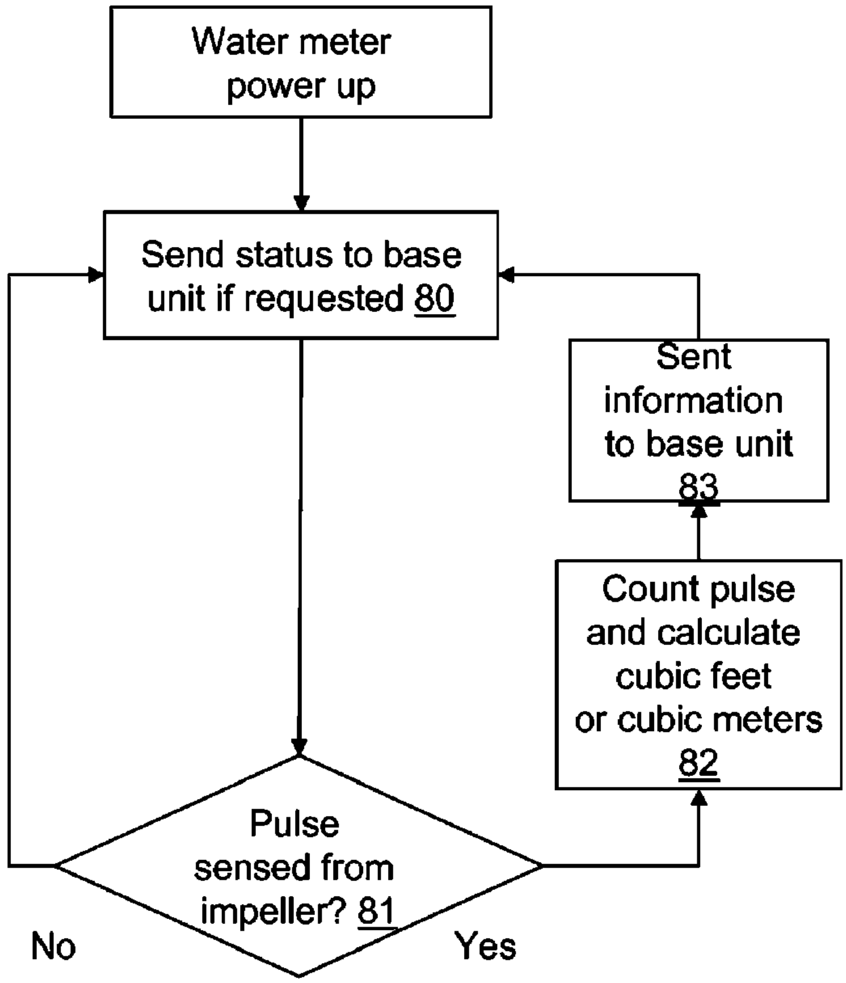

Water meter power up
Send status to base unit if requested 80
Sent information to base unit 83
Count pulse and calculate cubic feet or cubic meters 82
Pulse sensed from impeller? 81
No
Yes

FIG. 8

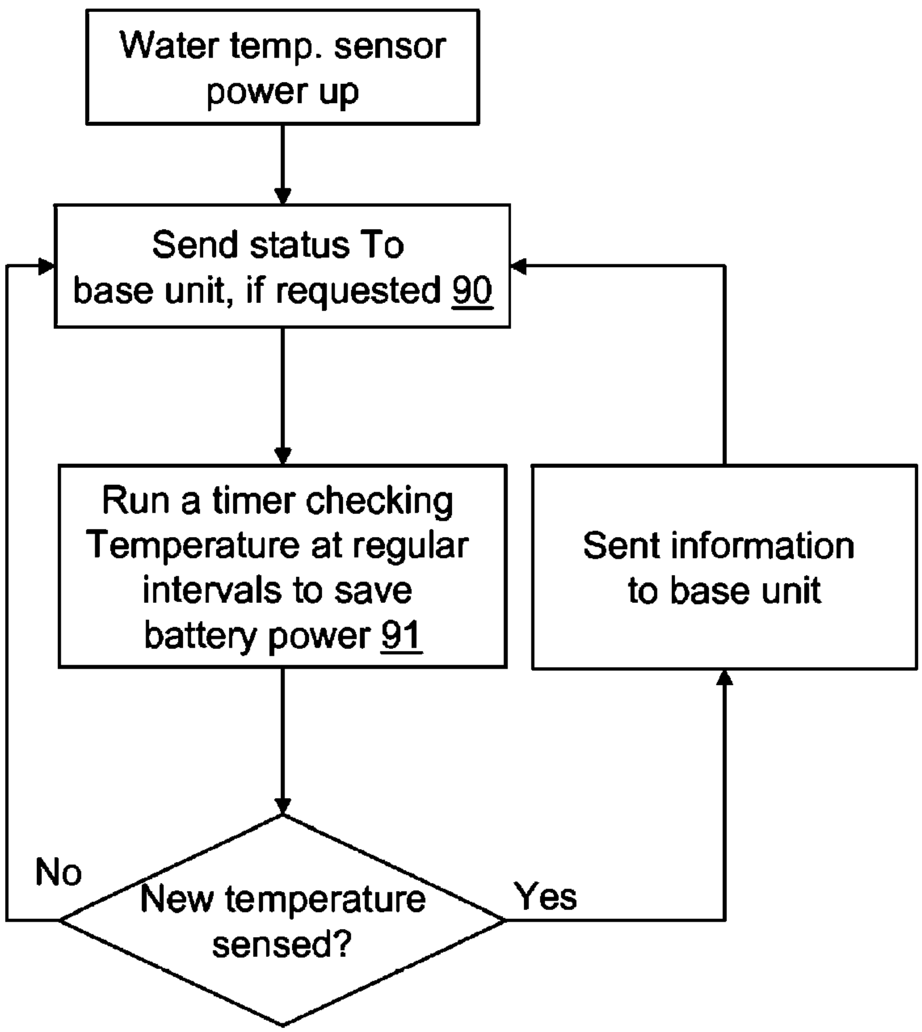

Water temp. sensor power up
Send status To base unit, if requested 90
Run a timer checking Temperature at regular intervals to save battery power 91
Sent information to base unit
No
New temperature sensed?
Yes

FIG. 9

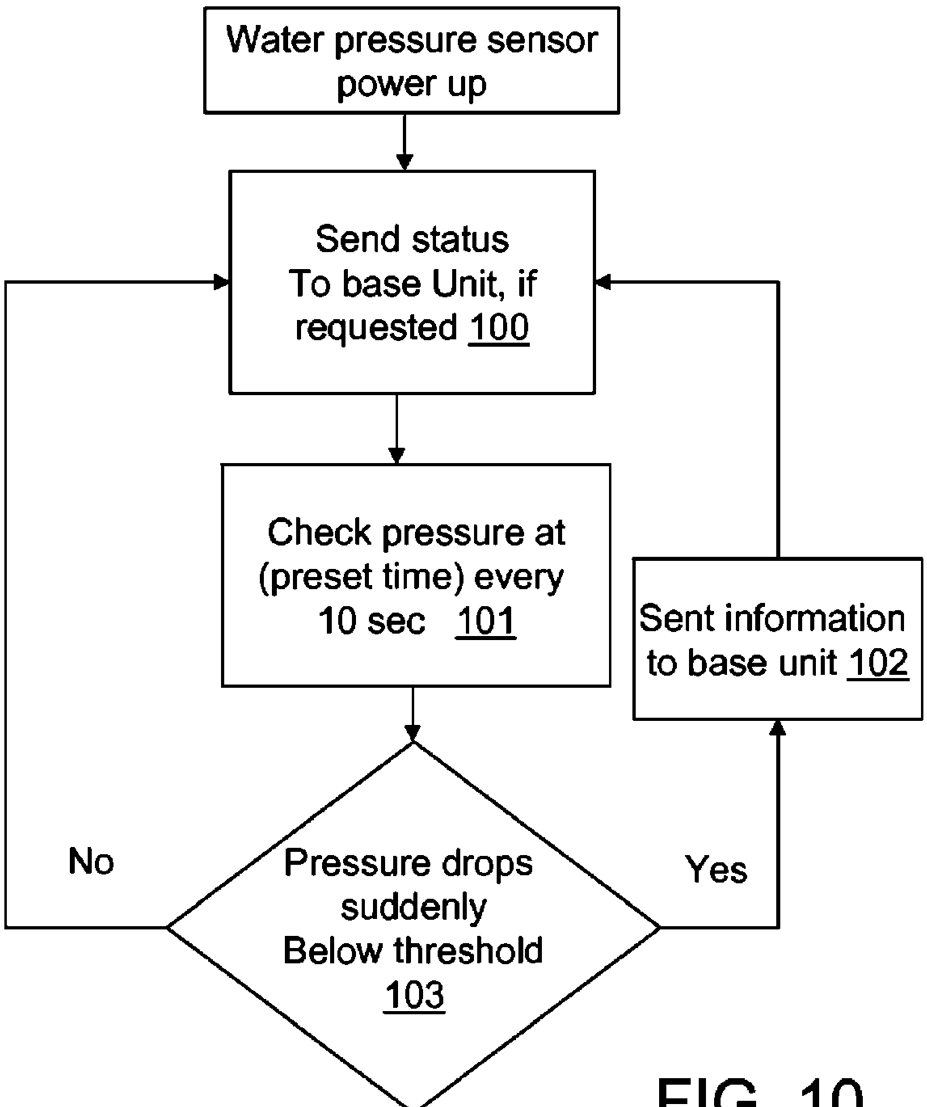

Water pressure sensor power up
Send status To base Unit, if requested 100
Check pressure at (preset time) every 10 sec 101
Sent information to base unit 102
Pressure drops suddenly Below threshold 103
No
Yes

FIG. 10

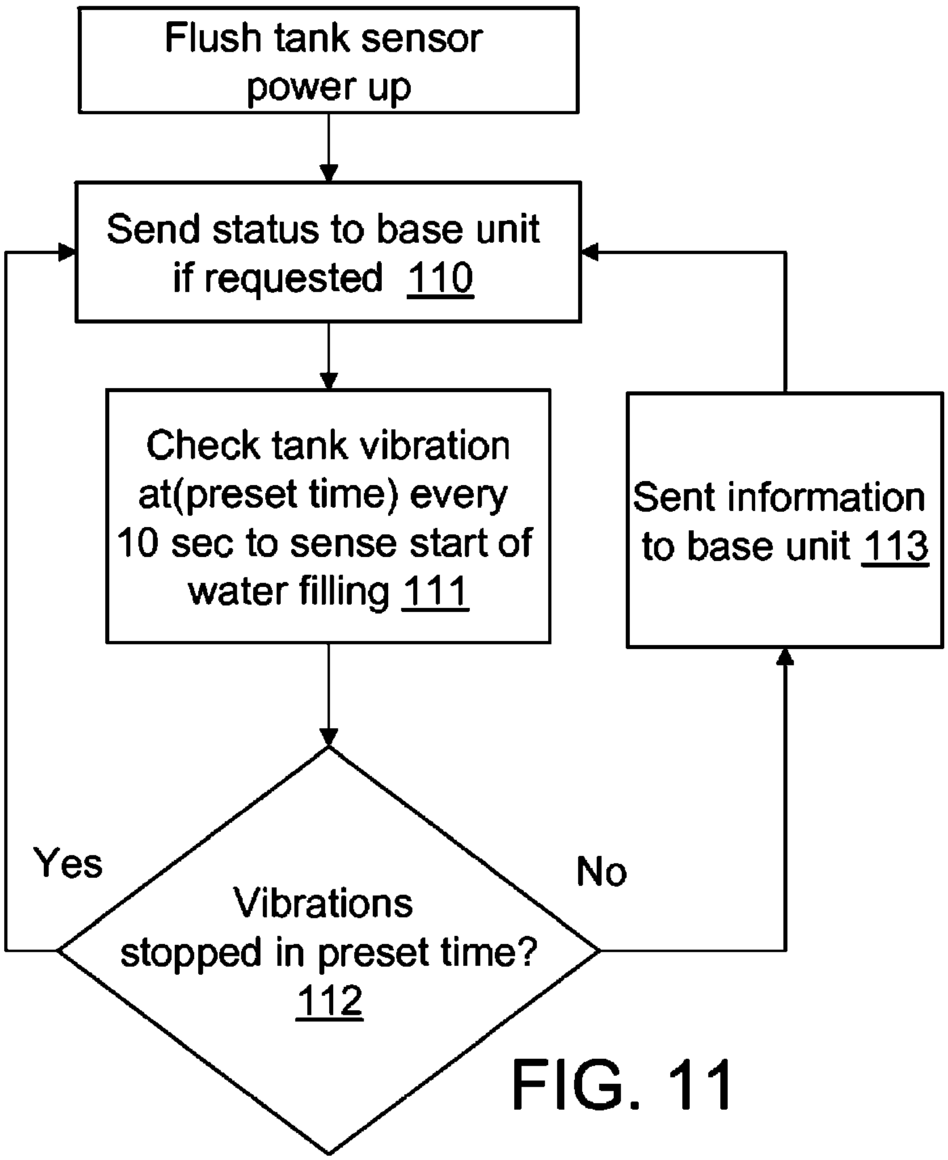

Flush tank sensor power up
Send status to base unit if requested 110
Check tank vibration at(preset time) every 10 sec to sense start of water filling 111
Sent information to base unit 113
Vibrations stopped in preset time? 112
Yes
No

FIG. 11

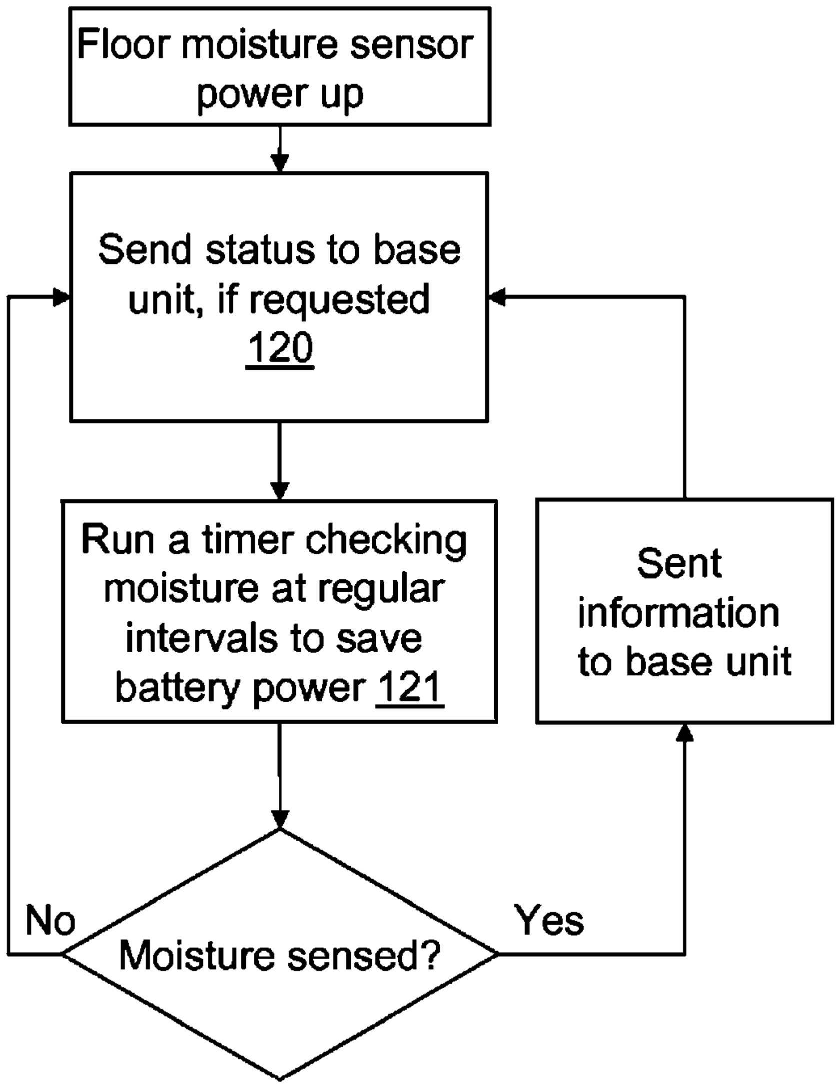

Floor moisture sensor power up
Send status to base unit, if requested 120
Run a timer checking moisture at regular intervals to save battery power 121
Sent information to base unit
No
Moisture sensed?
Yes

FIG. 12

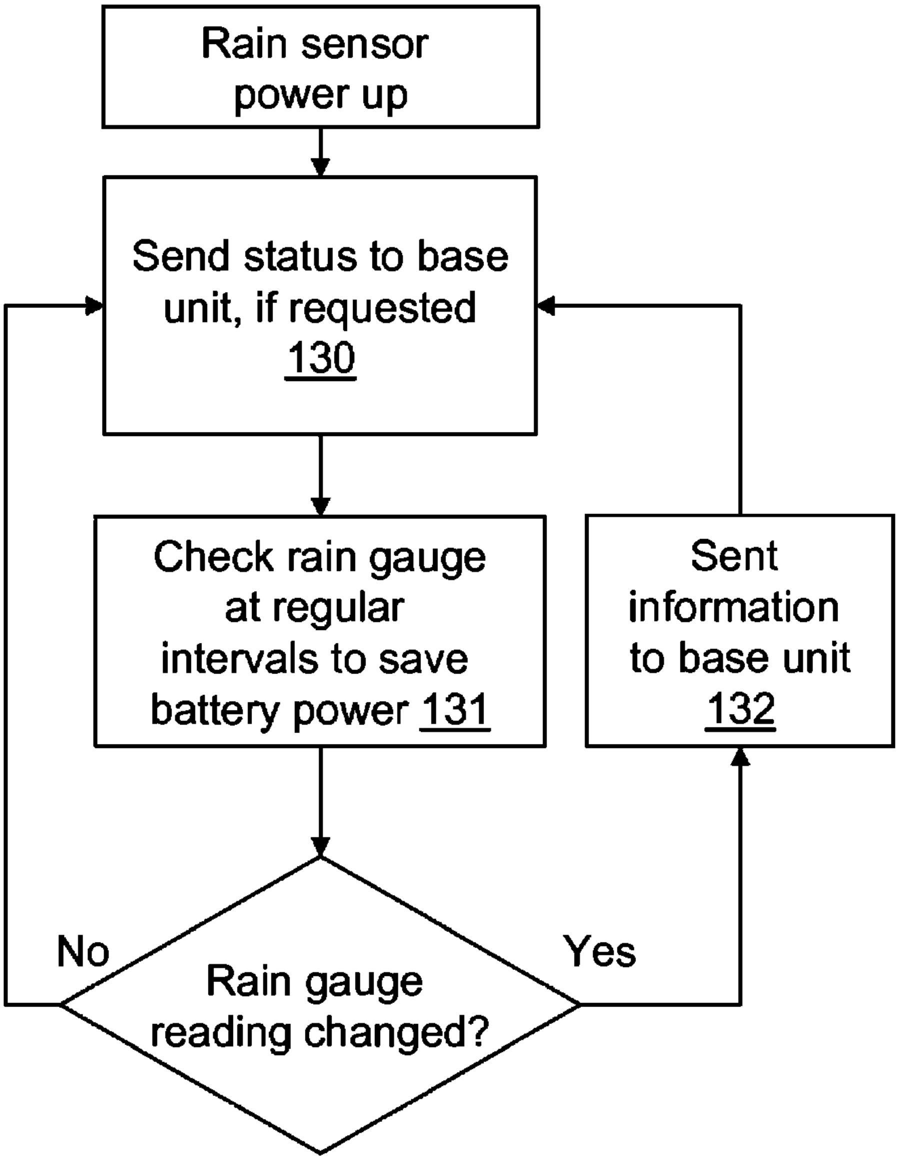
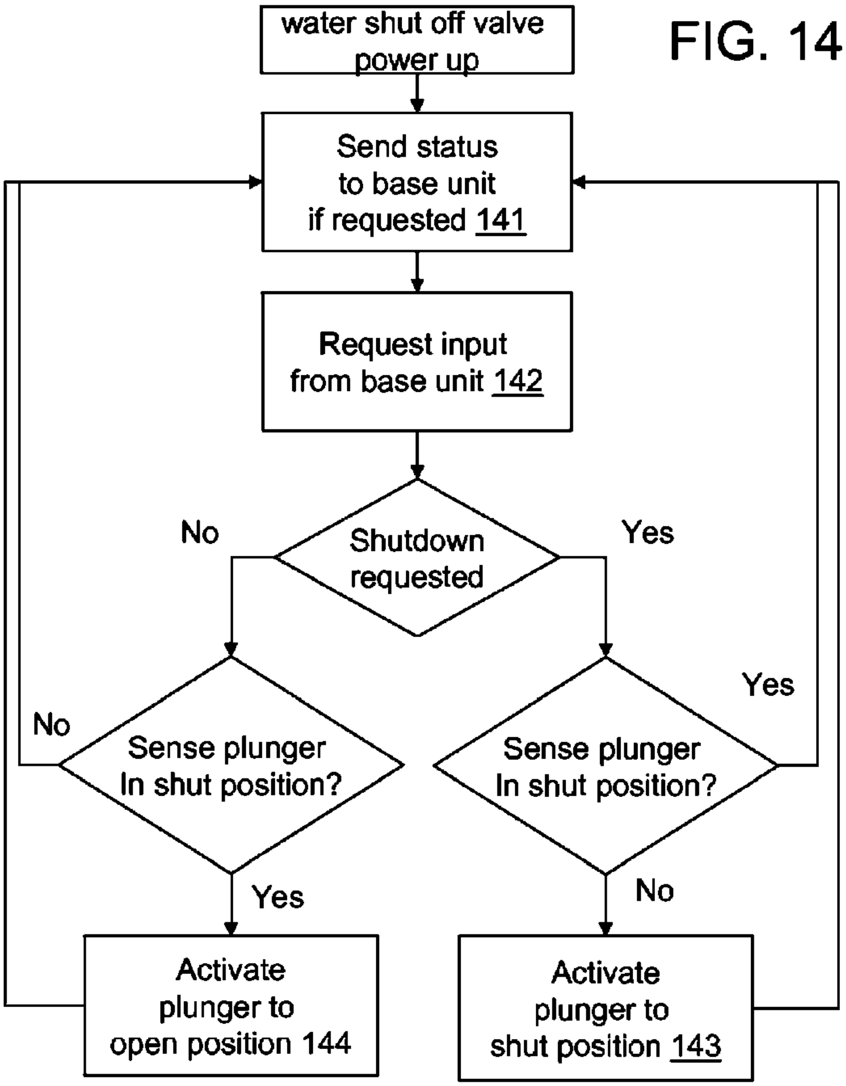

Rain sensor power up
Send status to base unit, if requested 130
Check rain gauge at regular intervals to save battery power 131
Sent information to base unit 132
Rain gauge reading changed?
No
Yes

FIG. 13

FIG. 14


water shut off valve power up
Send status to base unit if requested 141
Request input from base unit 142
Shutdown requested
No
Yes
Sense plunger In shut position?
No
Yes
Sense plunger In shut position?
Yes
No
Activate plunger to open position 144
Activate plunger to shut position 143

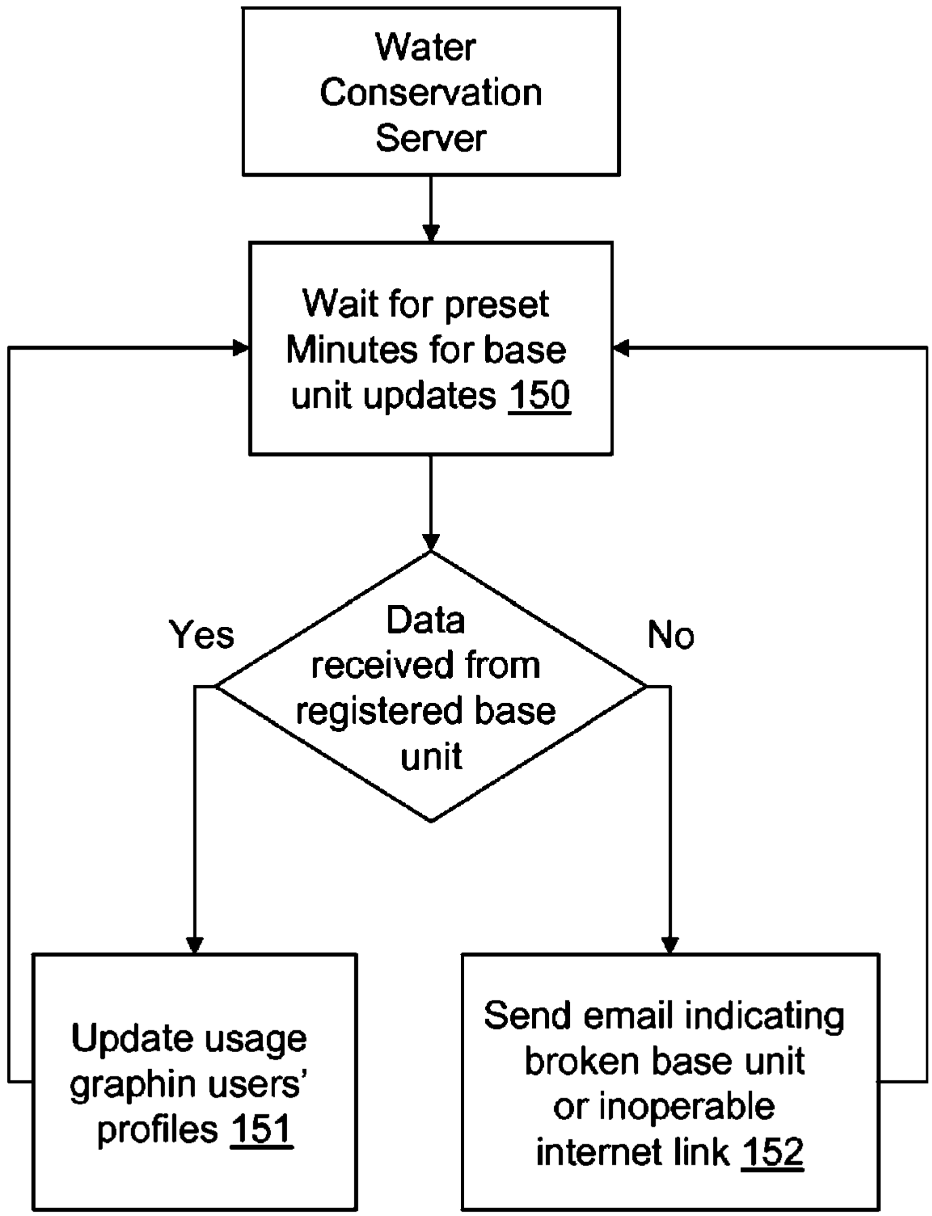

Water Conservation Server
Wait for preset Minutes for base unit updates 150
Yes
Data received from registered base unit
No
Update usage graphin users' profiles 151
Send email indicating broken base unit or inoperable internet link 152

FIG. 15

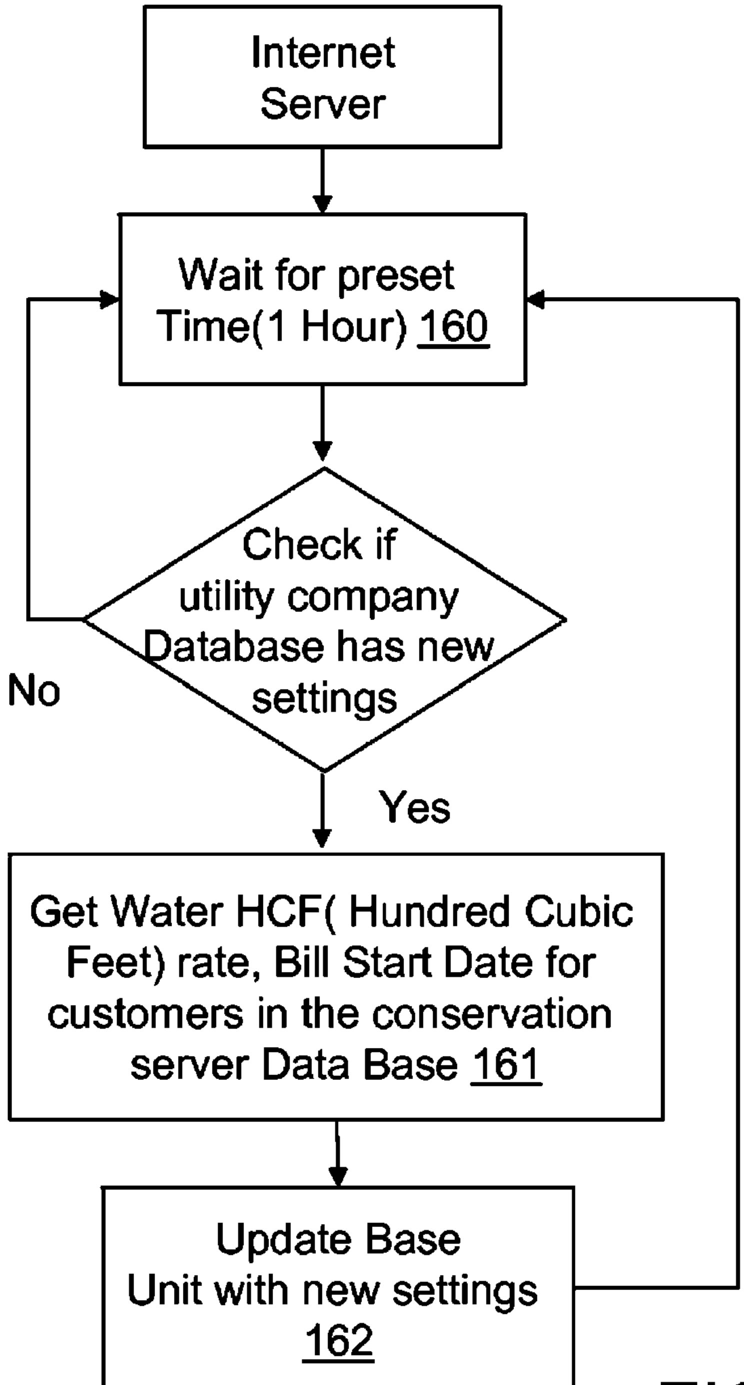

Internet Server
Wait for preset Time(1 Hour) 160
Check if utility company Database has new settings
No
Yes
Get Water HCF(Hundred Cubic Feet) rate, Bill Start Date for customers in the conservation server Data Base 161
Update Base Unit with new settings 162

FIG. 16

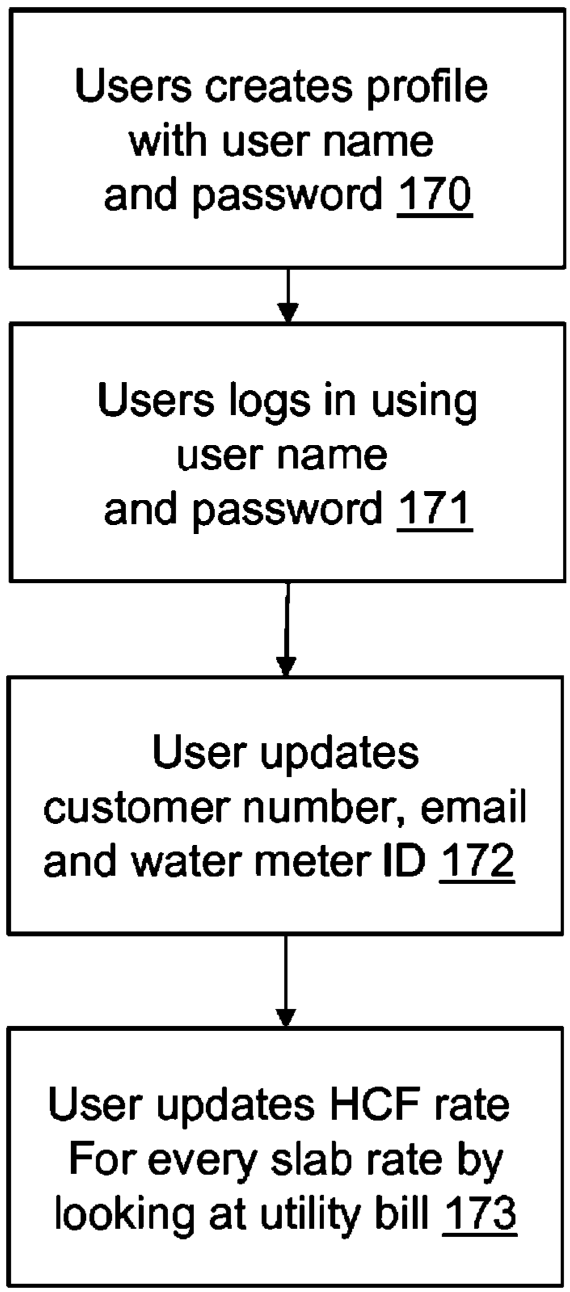

Users creates profile with user name and password 170
Users logs in using user name and password 171
User updates customer number, email and water meter ID 172
User updates HCF rate For every slab rate by looking at utility bill 173

FIG. 17

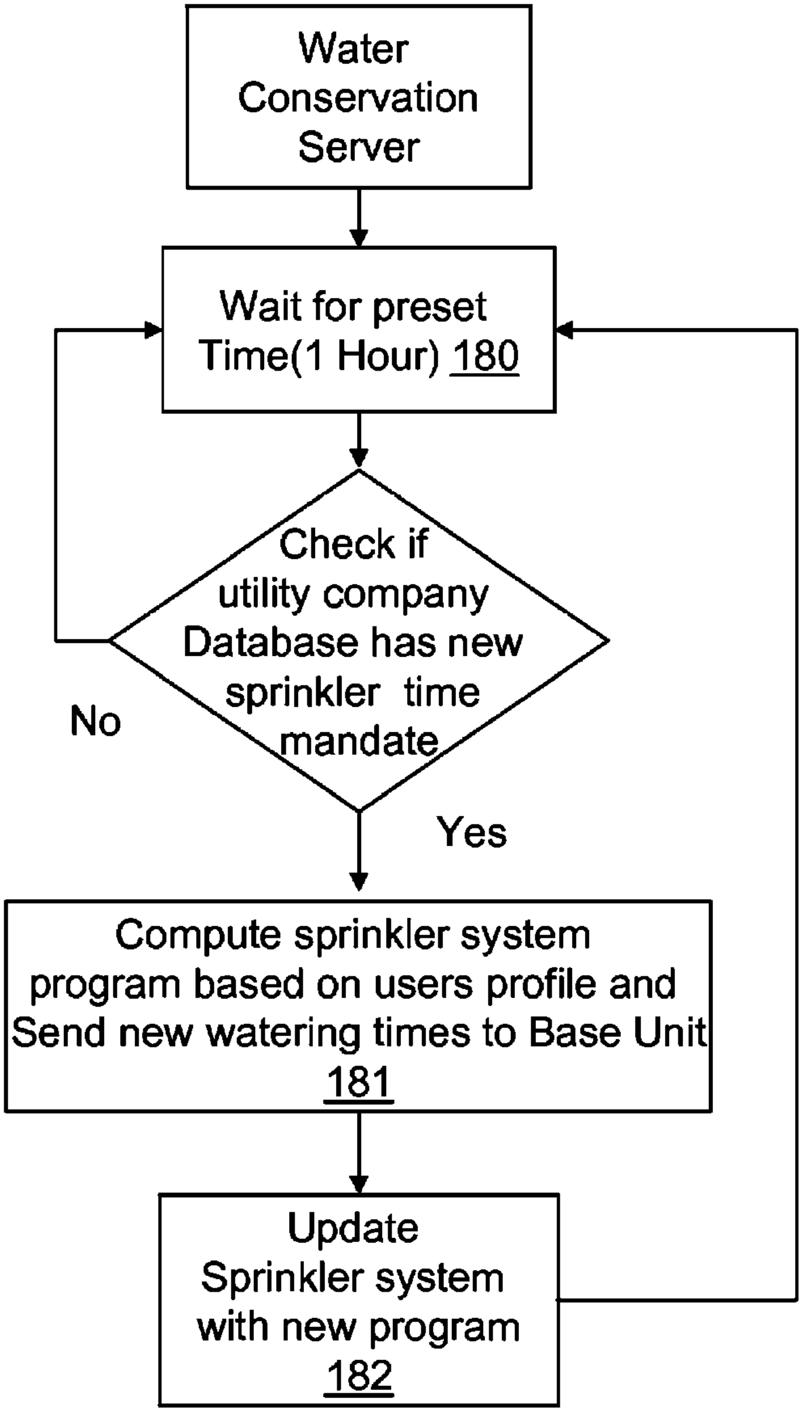

Water Conservation Server
Wait for preset Time(1 Hour) 180
Check if utility company Database has new sprinkler time mandate
No
Yes
Compute sprinkler system program based on users profile and Send new watering times to Base Unit 181
Update Sprinkler system with new program 182

FIG. 18

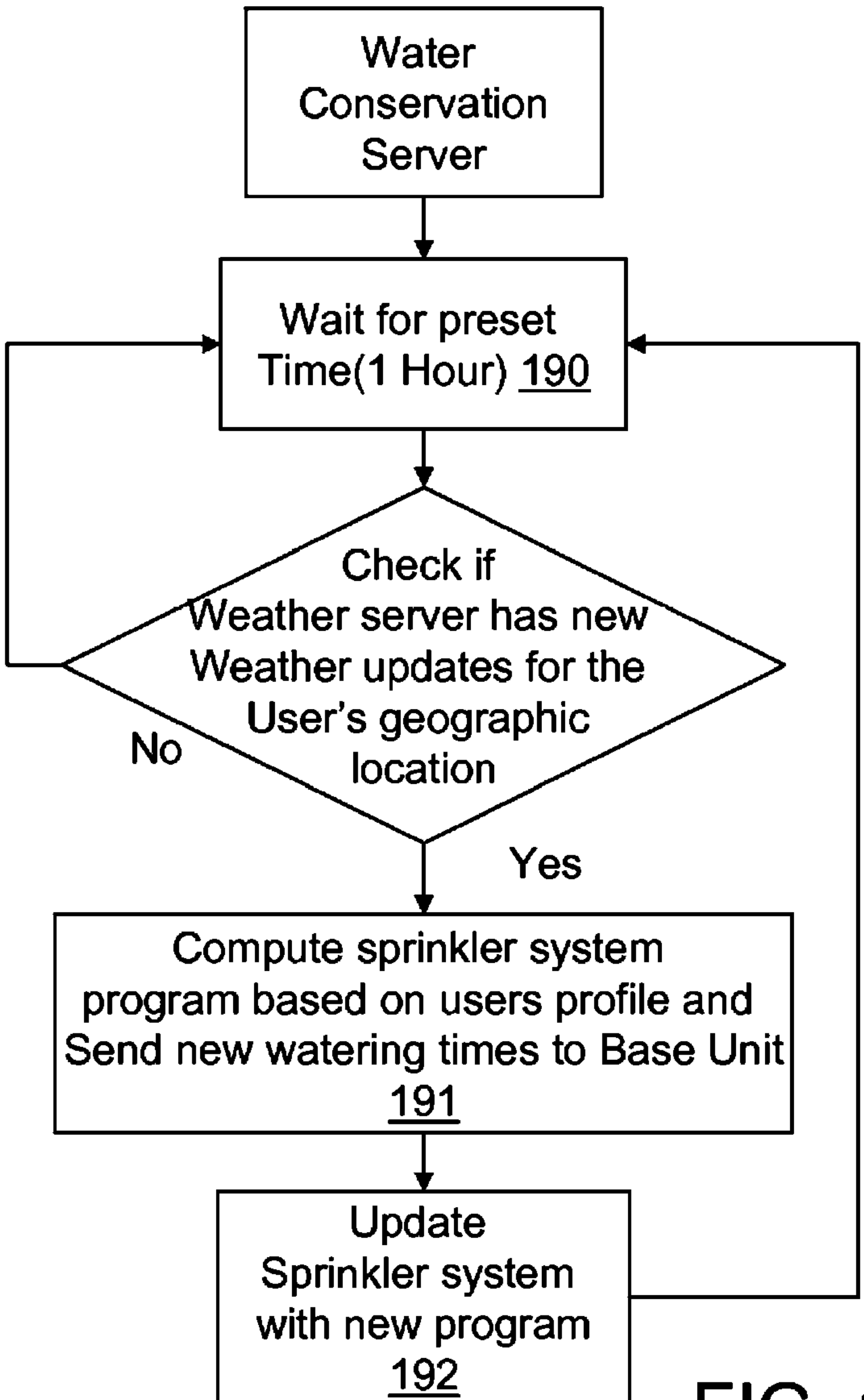

Water
Conservation
Server
Wait for preset
Time(1 Hour) 190
Check if
Weather server has new
Weather updates for the
User's geographic
location
No
Yes
Compute sprinkler system
program based on users profile and
Send new watering times to Base Unit
191
Update
Sprinkler system
with new program
192

FIG. 19

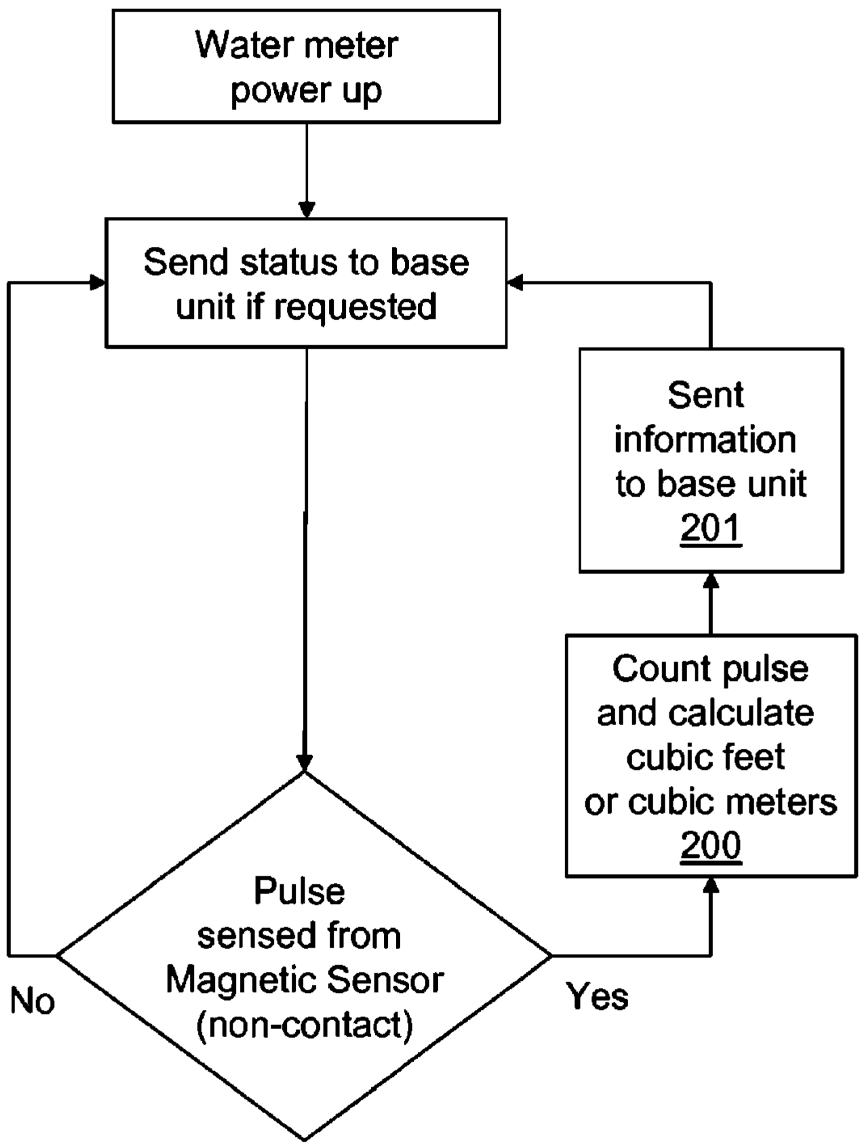

Water meter power up
Send status to base unit if requested
Sent information to base unit 201
Count pulse and calculate cubic feet or cubic meters 200
Pulse sensed from Magnetic Sensor (non-contact)
No
Yes

FIG. 20

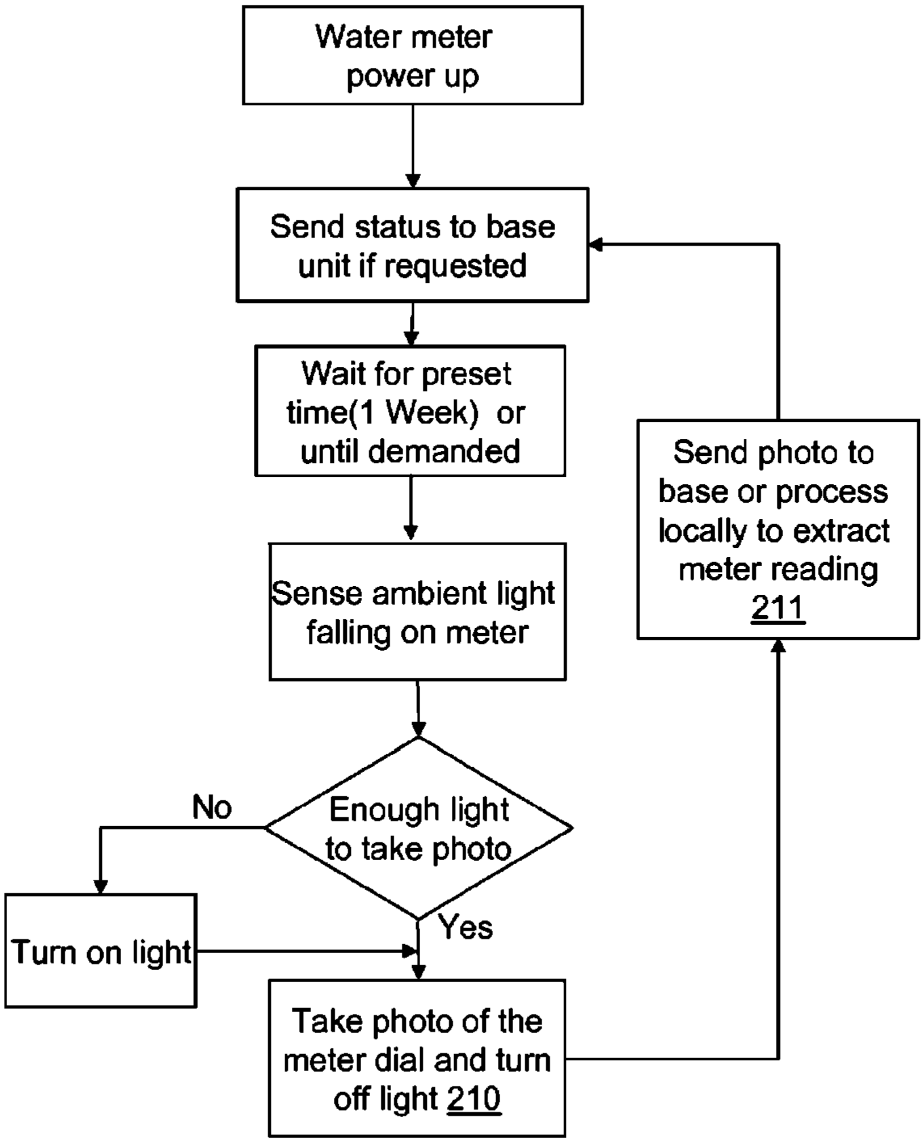

Water meter power up
Send status to base unit if requested
Wait for preset time(1 Week) or until demanded
Sense ambient light falling on meter
Enough light to take photo
No
Yes
Turn on light
Take photo of the meter dial and turn off light 210
Send photo to base or process locally to extract meter reading 211

FIG. 21

WATER MANAGEMENT SYSTEM

FIELD OF THE INVENTION

[0001] This invention claims the benefit of U.S. Provisional Applications No. 61/346,267, titled "Intelligent data logging, analysis system and/or subscription service for single and multi-site synchronous data, not limited to wind, solar analysis and water conservation applications" filed on May 19, 2010, and U.S. Provisional Applications No. 61/253,199 titled "Intelligent data logging and analysis system for single and multi-site synchronous data, not limited to wind and solar analysis applications and subscription service" filed on Oct. 20, 2009. Both of these applications are hereby incorporated by reference. Applicant claims priority pursuant to 35 U.S.C. Par 119(e)(i). The present invention relates to the monitoring and control of water consumption.

BACKGROUND

[0002] Freshwater is vital to health and to the economy, and reliable access to it is becoming increasingly important as the human population on Earth increases. Yet its availability is limited. Conservation is an important issue and therefore, water management tools are important, especially those tools that provide average households with the means for managing their own water consumption.

[0003] Many devices exist for monitoring and controlling water usage, but they provide limited functionality. For example water meters exist that allow consumers to measure their own water usage. These devices however have no time resolution or past history records. Users cannot tell exactly when water is being used and by whom. Water thermometers exist that allow consumers to measure the temperature of their hot water and indirectly the amount of energy they use for heating water. These thermometers, however, are not connected to a central control system that monitors energy usage. Water valves exist that allow users to shut off water flow but these devices are not connected to a central management system that can control their open or close status. Flood alarms exist but they are not integrated with a central water management system capable of shutting off water in case of a flood. Water pressure measurement systems exist but they are not integrated with a central management system capable of displaying pressure and of shutting off valves either in case of overpressure that could damage sprinklers or appliances, or in case of underpressure indicative of pipe breakage. Weather monitoring systems exist but are not integrated with a central water management system capable, for example of regulating lawn irrigation. Billing systems exist but they are not integrated with a central water management system. Furthermore these devices are limited in their capabilities to communicate with consumers. The Rain Bird Company is marketing a smart controller that can be used to control sprinkler time based on weather data from public weather server data. But this controller does not use water authority mandates that are put in place sometimes during droughts to change watering time into their schedules and is not integrated into a comprehensive water management system.

[0004] Current water monitoring systems only send the cumulative water flow measurement in the form of a count, every few hours. This relatively long time interval makes water consumption monitoring impossible to perform in real time.

[0005] None of the water meters have an integrated shut off value that can be activated remotely. The decision is made at the water companies to shut off water distribution.

[0006] None of the prior art offers the entertainment value of this invention. Further features, aspects, and advantages of the present invention over the prior art will be more fully understood when considered with respect to the following detailed description claims and accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0007] FIG. **1** illustrates the whole system, showing the base unit in communication with water sensors and actuators, and through the Internet, with a server, user computers, mobile devices, water companies and weather information services.

[0008] FIG. **2** provides a block diagram of the base unit which includes a microprocessor, a display, a data entry device, and a communication system.

[0009] FIG. **3** represents the functional flow diagram of the base unit.

[0010] FIG. **4** illustrates the power up sequence for the base unit.

[0011] FIG. **5** shows the functional block diagram for the sensor monitoring operation of the base unit.

[0012] FIG. **6** is a functional flow diagram of the decision process and quota utilization for the base unit.

[0013] FIG. **7** illustrates the functional flow diagram for outputting messages and alarms.

[0014] FIG. **8** shows the functional flow diagram for the operation of the water meter sensor.

[0015] FIG. **9** illustrates the functional flow diagram for the operation of the water temperature sensor.

[0016] FIG. **10** represents the functional flow diagram of the water pressure sensor.

[0017] FIG. **11** illustrates the functional flow diagram for the toilet flush sensor.

[0018] FIG. **12** shows the functional flow diagram for the floor moisture sensor used to detect floods.

[0019] FIG. **13** provides the flow diagram of the operation of a rain sensor.

[0020] FIG. **14** illustrates the functional flow diagram for the shut off valve actuator.

[0021] FIG. **15** shows the communication of the Internet server with each base unit.

[0022] FIG. **16** illustrates how the Internet server collects cost data from a water utility company and updates the base units according to this data.

[0023] FIG. **17** shows how the Internet server updates the user profile, water meter profile, and utility rates and water rates.

[0024] FIG. **18** illustrates how the Internet server collects mandated watering times from a water utility company and updates the base units and sprinklers according to this data

[0025] FIG. **19** illustrates how the Internet server collects weather data and updates the base units and sprinklers according to this data.

[0026] FIG. **20** illustrates how the fluctuating magnetic field near a water meter can be used to extract water usage information.

[0027] FIG. 21 shows how an optical technique can be used to read a water meter and extract water usage information.

SUMMARY OF THE INVENTION

[0028] This invention is a water consumption monitoring and control system that allows a user to monitor and control water consumption. It is comprised of a base unit which itself comprises

[0029] a) a display and a data entry device;

[0030] b) a microprocessor

[0031] c) a communication link connected to a water meter, through which water usage information is transmitted to the base unit.

[0032] d) a second communication link to the Internet through which a user can monitor and control his water usage. The water usage can be converted to a dollar amount for the benefit of the user.

[0033] The water consumption monitoring and control system is also connected to pressure sensors. The received pressure information is compared to pre-entered criteria. An alarm is generated if the pressure information does not conform to the pre-entered criteria. For example, a low pressure may indicate breakage or leak in a water pipe. This alarm is used to generate a message over the Internet in the form of email, tweet or text. Text messaging could use, for example, the Short Message Service (SMS) protocol.

[0034] The water consumption monitoring and control system is also connected to water shut-off valves. The received pressure information is compared with pre-entered criteria. A shut-off signal is generated if the pressure information does not conform to the pre-entered criteria. This shut-off signal is sent to the shut-off valves.

[0035] Communication is established over the Internet with the local water utility company. Water usage and pressure information is sent to the company which compares this data against pre-set usage and pressure criteria and sends shut-off command signals to the base unit if the information does not conform to the pre-set usage and pressure criteria. This shut off signal is forwarded to the shut-off valves. Possible reasons for shutting off the water supply is that the utility company may determine that the water is unsafe to drink or that customers have not paid their bills.

[0036] Communication is established over the Internet between the base unit and an Internet server. Water usage and pressure data are sent to the server which evaluates this information and returns usage control information to the base unit.

[0037] Water schedule advisories are received over the Internet from the local government water department. This data is used by the Internet server to generate government advisory control information which is sent to the base unit.

[0038] Weather information is received over the Internet from the weather office. This data is used by the Internet server to generate weather advisory control information which is sent to the base unit.

[0039] The base unit is also connected to, and can control the operation of, a sprinkler system.

[0040] Water temperature information is also transmitted to the base unit and used to calculate the energy used in heating water.

[0041] Floor moisture sensors that generate information regarding the absence or presence of a flood are also linked to the base unit. In the presence of a flood, an alarm is generated and an Internet message is sent to the user.

[0042] The base unit is also connected to vibration sensors configured to detect the vibrations produced by flushing toilets. Malfunctioning toilets which may take too long to fill can thus be identified.

[0043] The base unit can also be connected to several water meters, each water meter located in a different housing or commercial unit, thereby allowing the user (for example the landlord) to monitor the tenant's usage. Similarly the base unit can monitor water usage at different points within a single house.

[0044] The microprocessor in the base unit can record water usage as well as pressure and temperature information over a period of time and use this historical information to detect water wastage and to detect leaks and pipe breakage.

[0045] The base unit can also provide to the user the information regarding the water consumption of his neighbors (or user defined groups anywhere in the world like families, brother and sisters, college campus or special interest groups) and his rank in water usage, thereby stimulating water conservation through competitive thinking.

DETAILED DESCRIPTION

[0046] The system block diagram of the invention is shown in FIG. 1. It comprises the following components:

[0047] a) A display/control panel called the base unit. 1

[0048] b) A series of sensors including water temperature sensors 3, water pressure sensors 8, floor moisture sensors 7, vibration flush sensors 5, water meters 2, 4, rain sensors/gauge 16.

[0049] c) A series of actuators, such as shut off valves 13.

[0050] d) Communication links to several entities located on the Web in particular a server 9, a utility company 14 (water company), a weather information service 15 and user mobile communication devices (e.g., cell phones)

[0051] e) An internet server 9

[0052] f) Desk top or lap top computers 10

[0053] g) User mobile communication devices 11

[0054] The base unit 1 is configured to monitor and control water consumption. The block diagram of the base unit is shown in FIG. 2. It comprises a microcontroller 21, a display 21, a data entry device 22 and at least one communication link 23.

[0055] The communication links 23 can include communication from the sensors to the actuators. This communication can be implemented by means of a wire or wirelessly for example, by means of ISM band transceivers, Zigbee or WiFi. The communication also includes access to the Internet, either wirelessly, or by means of a wired ethernet.

[0056] The overall operation of the microcontroller 20 is illustrated in the flow diagrams provided in FIG. 3. It includes

[0057] a) a power up sequence 30,

[0058] b) inputting sensor data 31,

[0059] c) quota evaluation and monitoring 32, and

[0060] d) outputting system status and alarm data 33.

[0061] The power up sequence 30 is illustrated in detail in FIG. 4. It includes the following:

[0062] a) powering up 40 the base unit 1,

[0063] b) verifying 41 that the connection to the water conservation server on the Internet is working,

[0064] c) verifying 42 that the wired or wireless connections to the sensors and actuators are operational,

[0065] d) displaying 43 the status of the system,

[0066] e) sending an alarm 44 in case of system failure,

[0067] f) starting the Control Logic (1) software 45 which inputs sensor data and monitors sensor operation. This software is shown in greater detail in FIG. 5.

[0068] Inputting software data and monitoring software operation performed by Control Logic (1) 45 is shown in detail in FIG. 5. Data is received from flow sensors (water meters) 50, temperature sensors 51, pressure sensors 52, flood sensors 53, rain sensors/gauge 54, and vibration sensors 55. If this information has changed, the Control Logic (2) software 56 is invoked, the display is updated 57, and the Internet server is also updated 58.

[0069] The Control Logic (2) software is illustrated in detail in FIG. 6. The collected sensor data is compared against a set of quotas, limits or decision paradigms entered by the user or received from the server through the Internet. For example, a quota could be a daily threshold, or a monthly allowance for water usage, not to be exceeded. A decision paradigm could be a low level flow over a long period of time, which may indicate a leak in a faucet, toilet or other appliance. A decision paradigm could also be an overall low water consumption level worthy of signaling to the users as a sign that they are saving water. If a quota is exceeded or if a decision paradigm is triggered, the next step of the process as embodied in Control Logic (3) 60 is invoked.

[0070] Control Logic (3) is shown in detail in FIG. 7. Depending on the alarm configuration as set up by the user different actions are undertaken. For example, an email, SMS or twitter messages can be sent 70 over the Internet, a buzzer can be activated 71 or a water valve can be shut off 72.

[0071] Each component of the system, peripheral to the base unit 1 is equipped with the link necessary to communicate with the base unit 1. For example, the operation of the water meter 2, 4 is shown in FIG. 8. Upon powering up, the water meter performs the following cycle.

[0072] a) It sends status information to the base unit 1 if requested 80.

[0073] b) It measures the water flow 81.

[0074] c) It calculates the flow from count pulse and converts this flow to cubic feet or cubic meters 82. Then it sends 83 this information to the base unit.

[0075] Another sensor of interest is the water temperature sensor 3 which indirectly indicates the amount of energy spent in heating water. The flow diagram for this sensor is shown in FIG. 9. Upon powering up, the sensor status is sent to the base unit 1 if requested 90. To save power, the temperature is sampled 91 at time intervals as instructed by the base unit 1. If a new temperature is detected this information is sent to the base unit 1.

[0076] The water pressure sensor 8 is important because overpressure may damage the piping system, and appliances such as refrigerators, ice makers, and washing machines. High pressure can also damage low pressure drip irrigation often used in residential yards. The detailed operation of the pressure sensor 8 is shown in FIG. 10. Upon powering up, the sensor sends 100 its status to the base unit 1 if requested. To save power, the pressure is sampled 101 at time intervals as instructed by the base unit 1 and this information is sent 102 to the base unit 1. Optionally the pressure can be compared 103 to a preset threshold and send to the base unit 1 if it exceeds the threshold. Pressure monitoring is valuable in the detection of broken pipes in water lines, in particular in sprinkler systems.

[0077] The flush tank sensor 5 can be implemented in many possible ways. For example it can sense the water lever in the tank. A preferred implementation is for this sensor to sense the vibration in the water line produced by the tank filling. The detailed operation of the flush tank sensor 5 is illustrated in FIG. 11. Upon power up, the sensor sends 110 its status to the base unit. To save power, it measures vibrations at preset time intervals as instructed by the base unit 1 to sense the onset of water filling 111. If the vibrations do not stop 112 after a preset time (for example 5 minutes) it sends 113 this information to the base unit as this situation may indicate a malfunction of the flushing system.

[0078] The floor moisture sensor 7 is important to detect flooding. It operation is shown in FIG. 12. Upon power up, it sends 120 its status to the base unit. To save power, it samples 121 the floor moisture at preset time intervals as instructed by the base unit 1 and sends this information to the base unit 1.

[0079] The rain sensor/gauge 16 measures rain and allows adjustment of the irrigation schedule. It operation is shown in FIG. 13. Upon power up, it sends 130 its status to the base unit. To save power, it reads 131 the gauge at preset time intervals as instructed by the base unit 1 and sends this information to the base unit 1.

[0080] The shut off valve turns off water if one of the decision paradigms is met. For example, when excessive water usage has occurred over a given period of time. As illustrated in FIG. 14, upon power up, this actuator sends its status to the base unit. If a shut down is requested 142 and if the valve is in an open state, the actuator activates the valve to shut off 143 the water. Otherwise, if the valve is in a closed state it activates the valve to remain open 144 and maintain the water flowing.

[0081] Additional processing can be performed either at the Internet server or at the base unit. For example the energy consumed for heating water can be calculated by measuring the cold and hot water temperature and the hot water flow. This energy can be displayed in energy units (for example Watts or BTUs) or in dollars if an appropriate conversion factor is entered into the device.

[0082] As illustrated in FIG. 1 the base unit 1 communicates with an Internet server 9. Details of this interaction are presented in FIGS. 15, 16 and 17.

[0083] FIG. 15 shows the communication between the Internet server 9 and one of the base units 1. The server waits 150 for the base unit 1 to communicate. If the server 9 receives new information, this information is incorporated into the user profile database. For example, the water usage graph could be updated 151. If the server 9 does not receive any message for a period exceeding a preset value, for example 15 minutes, an email is sent 152 to the user to notify him that the communication link with the server is inoperative or that the base unit is not functioning.

[0084] As shown in FIG. 1, the Internet server 9 also communicates with the water utility company server 14. This interaction at the Internet server 9 is illustrated in greater detail in FIG. 16. The Internet server checks 160 if the utility company has any new data affecting the utilization, availability and cost of the utility (water). The server performs this action at preset time intervals (for example one hour). In particular, it updates 161 the utility rate (typically measured in hundred cubic feet—HCF) and the bill start date.

[0085] As illustrated in FIG. 17, the Internet server 9 also allows users to create 170 a profile, and to log in 171 with a user name and password. The user can enter, or update 172 his customer number, email address, and water meter ID. The user can also enter or update 173 his usage and the cost

schedule used by the utility company. For example, water companies charge a lower rate for the first water quota (for example $3 for the first HCF) and then a higher rate if the user exceed that quota and even more for the next quota. These quotas of HCFs are also called first slab, second slab etc.

[0086] The base unit gets billing information from the water utility company to display water usage in dollars. Alternatively this billing information can be manually entered by the user.

[0087] Similarly the Internet server can get mandated watering time for irrigation sprinklers from the utility company. As shown in FIG. 18, the Internet server queries 180 the utility company every preset time interval. If new data is present, it transmits 181 this information to the base unit 1 which then updates 182 its watering schedule accordingly.

[0088] As illustrated in FIG. 1, the Internet server 9 obtains weather information 15 from the national climate data center currently located at www.ncdc.noaa.gov. The server 9 can also obtain weather information from servers for the national digital forecast database XML/SOAP service currently located at www.weather.gov.gov/xml. These servers support requests from other computers and send data about a geographical area in XML format.

[0089] Weather information can also be used to optimize water consumption as shown in FIG. 19. The Internet server 9 requests from the public weather servers, weather data corresponding to the geographical location of each base unit. The server 9 queries 190 the weather information server every preset time interval. When it receives new information, it computes 191 a sprinkler schedule and sends this schedule to on the base unit. 1. The base unit, in turn, updates 192 the sprinkler system.

[0090] The government mandated watering schedule is also used by the server 9 to calculate watering schedules (for example weekly/daily). This schedule is then sent to the base unit 1 and used to activate the sprinklers.

[0091] The internet server can also communicate with the water company to retrieve water usage rates, discount or overcharge hours, water quality advisories.

[0092] Floor moisture sensors 6 and 7 that generate information regarding the absence or presence of a flood are also linked to the base unit 1. In the presence of a flood, an alarm is generated and an Internet message is sent to the user.

[0093] This invention can also be used to monitor water usage at different points around a house or in a residential complex, and allows the identification of problematic and wasteful water consumption behavior and usage.

[0094] Several enhancements can facilitate the incorporation of conventional water meter into this invention. The following techniques may be used.

[0095] Typical water meter usually count the rotations of an impeller immersed in the water to obtain a measure of the flow. The meter senses the fluctuation of the magnetic field produced by the motion of a magnet coupled to the impeller to generate a count proportional to the water usage. This fluctuating magnetic field can be sensed outside the meter by means of a magnetic field sensor based on the Hall effect. As illustrated in FIG. 20 a magnetic sensor external to the water meter can be used to independently obtain 200 a measure of the water usage which may then be transmitted 201 to the base unit.

[0096] Sometimes, the magnetic field is intentionally shielded by the water meter manufacturers to prevent tempering with the meter's operation. In these cases, as shown in FIG. 21 it is possible to use an optical method to read the meter dial and to obtain a measure of water usage. For example a CCD camera can take pictures 210 of the dial and this picture can be processed to extract counter information.

[0097] It is evident to those skilled in the arts that the same technology as this invention can be used to monitor other utilities such as gas and electricity. The peripherals to monitor in these cases include watt-meters and gas meters. If solar energy is produced in the home, solar panels are peripheral that can also be included.

[0098] While the above description contains much specificity, the reader should not construe this as limitations on the scope of the invention, but merely as examples of preferred embodiments thereof. Those skilled in the art will envision many other possible variations within its scope. Accordingly, the reader is requested to determine the scope of the invention by the appended claims and their legal equivalents, and not by the examples which have been given.

I claim:

1. A water consumption monitoring and control system that allows a user to monitor and control water consumption, comprised of a base unit, said base unit comprising

a) a display and a data entry device;

b) a microprocessor functionally connected to said display and said data entry device;

c) a first communication link to at least one water meter, said first communication link functionally connected to said microprocessor, and transmitting water usage from said water meter to said base unit;

d) a second communication link to the Internet, said second communication link functionally connected to said microprocessor, and transmitting said water usage from said base unit to said user over the Internet.

2. The water consumption monitoring and control system of claim 1 wherein said microprocessor converts said water usage to monetary amounts and makes available the display of said monetary amounts to said user over the Internet.

3. The water consumption monitoring and control system of claim 1 also comprising a communication link to at least one pressure sensor, wherein said at least one pressure sensor sends water pressure information to said base unit wherein said microprocessor compares said pressure information with pre-entered criteria and generates an alarm if said pressure information does not conform with said pre-entered criteria.

4. The water consumption monitoring and control system of claim 3 wherein a message over the Internet is generated if said alarm is triggered, said message being in the form of email, tweet, or text.

5. The water consumption monitoring and control system of claim 3 also comprising a communication link to at least one water shut-off valve, wherein said at least one pressure sensor sends water pressure information to said base unit wherein said microprocessor compares said pressure information with pre-entered criteria and generates a shut-off signal if said pressure information does not conform with said pre-entered criteria, said shut off signal being sent to said at least one shut-off valve.

6. The water consumption monitoring and control system of claim 5 wherein said pre-entered criteria includes water leak and pipe breakage profiles and is used to detect said leak or said breakage.

7. The water consumption monitoring and control system of claim 5 wherein said second communication link to the Internet establishes communication between said base unit

and local water utility company, said water usage and said pressure information being sent to said utility company, wherein said utility company evaluates said water usage and said pressure information against pre-set usage and pressure criteria, and sends said shut-off command signals to said base unit if said water usage and pressure information does not conform to said pre-set usage and pressure criteria, said shut off signal being forwarded to said at least one shut-off valve.

8. The water consumption monitoring and control system of claim **3** wherein said second communication link to the Internet establishes communication between said base unit and an Internet server, wherein said second communication link carries said water usage and said pressure information to said server, and wherein said server evaluates said water usage and said pressure, generates usage control information and returns usage control information to said base unit through said second communication link.

9. The water consumption monitoring and control system of claim **1** wherein said second communication link to the Internet establishes communication between said base unit and an Internet server, wherein said second communication link carries water usage information to said server, and wherein said server evaluates said water usage, generates usage control information and returns usage control information to said base unit through said communication link.

10. The water consumption monitoring and control system of claim **1**, wherein said second communication link to the Internet establishes communication between said base unit and an Internet server, and furthermore wherein said Internet server receives water schedule advisories from the local government water department and generates government advisory control information, and sends said government advisory control information to said base unit.

11. The water consumption monitoring and control system of claim **1**, wherein said second communication link to the Internet establishes communication between said base unit and an Internet server, and furthermore wherein said Internet server receives weather information from the weather office and generates weather advisory control information, and sends said weather advisory control information to said base unit.

12. The water consumption monitoring and control system of claim **1**, also comprising a communication link to a sprinkler system, said sprinkler communication link carrying sprinkler control information to said sprinkler system.

13. The water consumption monitoring and control system of claim **1**, also comprising a communication link to at least one water temperature sensor, said temperature communication link carrying temperature information from said temperature sensors to said base unit, said temperature information being used to calculate energy usage in heating up water.

14. The water consumption monitoring and control system of claim **1**, also comprising a communication link to at least one vibration sensor, said vibration sensor configured to detect vibration produced by the operation of a flush toilet tank, said communication link carrying vibration data to said base unit, said vibration data being used to monitor the operation and detect malfunctions of said flush toilet tank.

15. The water consumption monitoring and control system of claim **1**, also comprising a communication link to at least one floor moisture sensor, said moisture sensor link carrying floor moisture data indicative of the presence or absence of a flood, said moisture data being used to generate, if appropriate, an alarm signal and a message over the internet to said user.

16. The water consumption monitoring and control system of claim **1**, comprising at least two water meters, wherein each said at least two water meters are located in different housing units.

17. A method for monitoring and controlling water consumption comprising:

a) monitoring water usage;

b) monitoring water pressure;

c) detecting breakage or leaks in water pipes by comparing, over time, said water pressure and said water usage to predetermined criteria;

d) issuing shut-off command if such said breakage or said leak is detected.

18. The method for monitoring and controlling water consumption of claim **17** also comprising issuing an internet message, said message being in the form of email, tweet or text.

19. The method for monitoring and controlling water consumption of claim **17** also comprising:

a) obtaining weather information from weather office

b) calculating watering schedule using said weather information

20. The method for monitoring and controlling water consumption of claim **17** also comprising:

a) obtaining watering advisories from local government office

b) calculating watering schedule using said watering advisories.

* * * * *

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(54) **ENERGY MANAGER—WATER LEAK DETECTION**

(75) Inventors: **Jay Andrew Broniak**, Louisville, KY (US); **Michael Thomas Beyerle**, Pewee Valley, KY (US); **Joseph Mark Brian**, Louisville, KY (US); **David C. Bingham**, Louisville, KY (US)

(73) Assignee: **General Electric Company**, Schenectady, NY (US)

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G01M 3/28	(2006.01)
E03B 7/07	(2006.01)

(52) **U.S. Cl.**
CPC ***G01M 3/2807*** (2013.01); ***E03B 7/075*** (2013.01)

(58) **Field of Classification Search**
CPC G01F 15/06–15/07
USPC 340/870.02, 606, 605; 73/46, 195; 702/45, 46, 100
See application file for complete search history.

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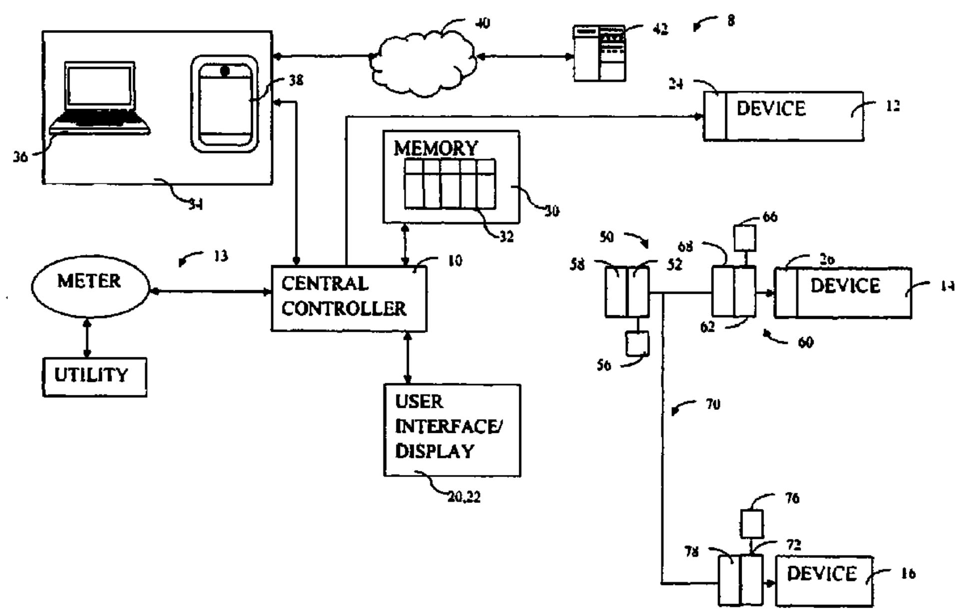
Primary Examiner — Albert Wong
(74) *Attorney, Agent, or Firm* — GE Global Patent Operation; Marc A. Vivenzio

(57) **ABSTRACT**

Methods and systems are disclosed for monitoring water leaks within a home. A home network with various devices monitors these devices with a controller. Information is received from a water flow meter via a transceiver for tracking a total water flow amount through pipelines in the home. By comparing information collected to a predetermined threshold, a leak is determined as present or not within each pipeline. Upon the detection of a leak in the home, a home owner is notified of the condition so that action is taken expeditiously. A shut off valve can be triggered remotely when a request is received from the user, which closes the water pipeline to prevent water damage.

18 Claims, 3 Drawing Sheets



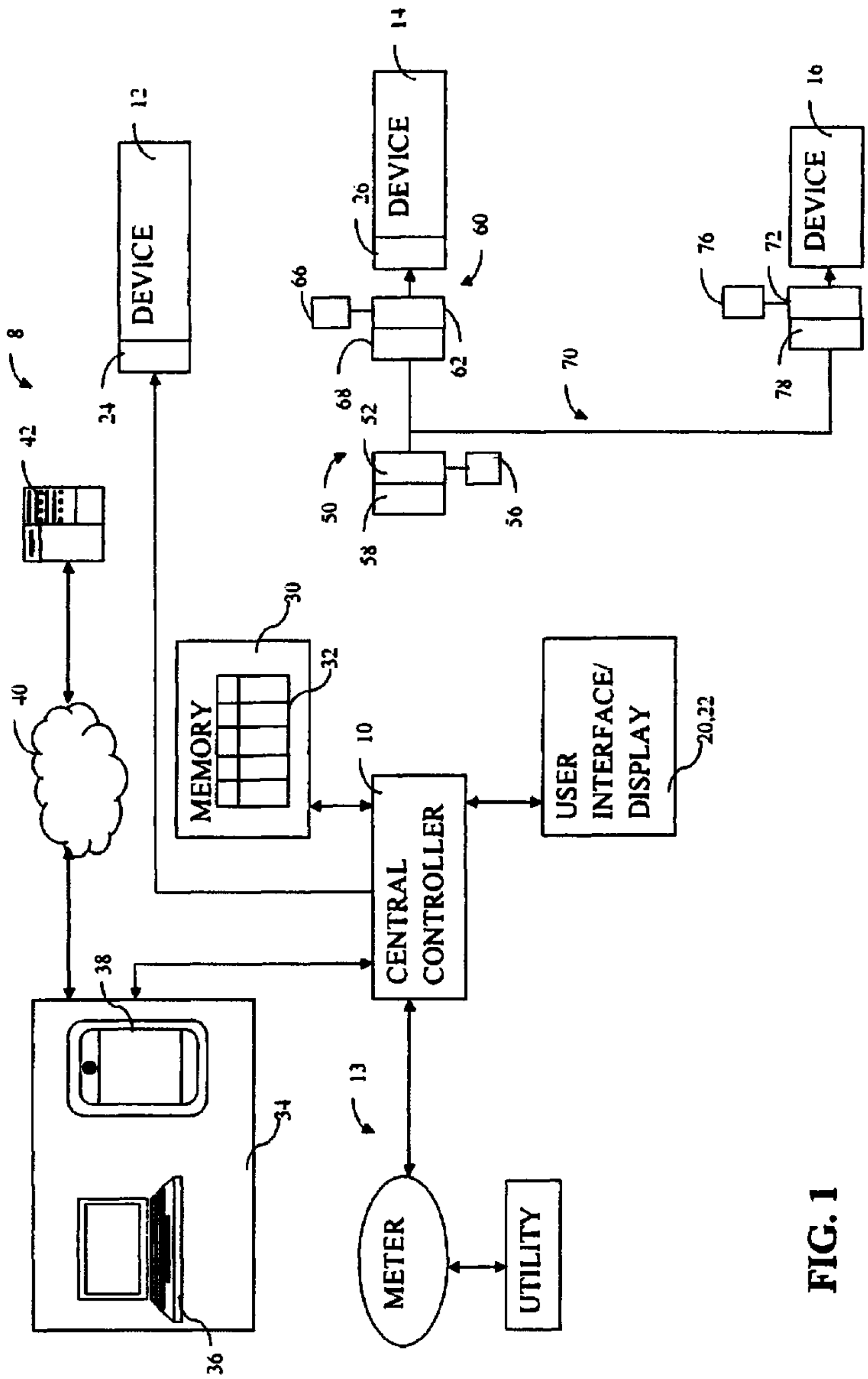

DEVICE
DEVICE
DEVICE
MEMORY
CENTRAL CONTROLLER
USER INTERFACE/ DISPLAY
METER
UTILITY

FIG. 1

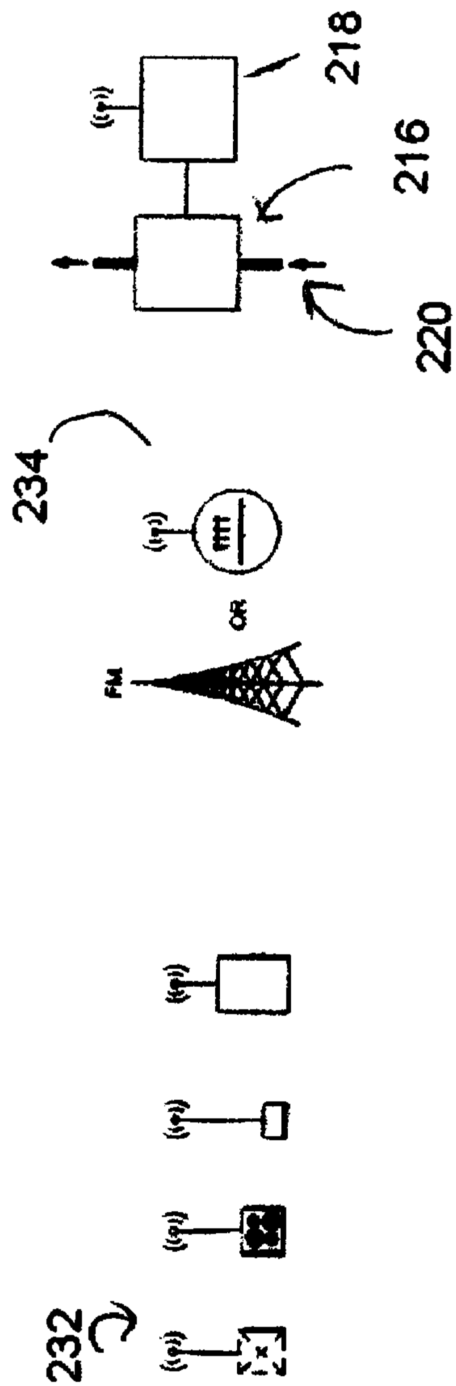


FIG. 2

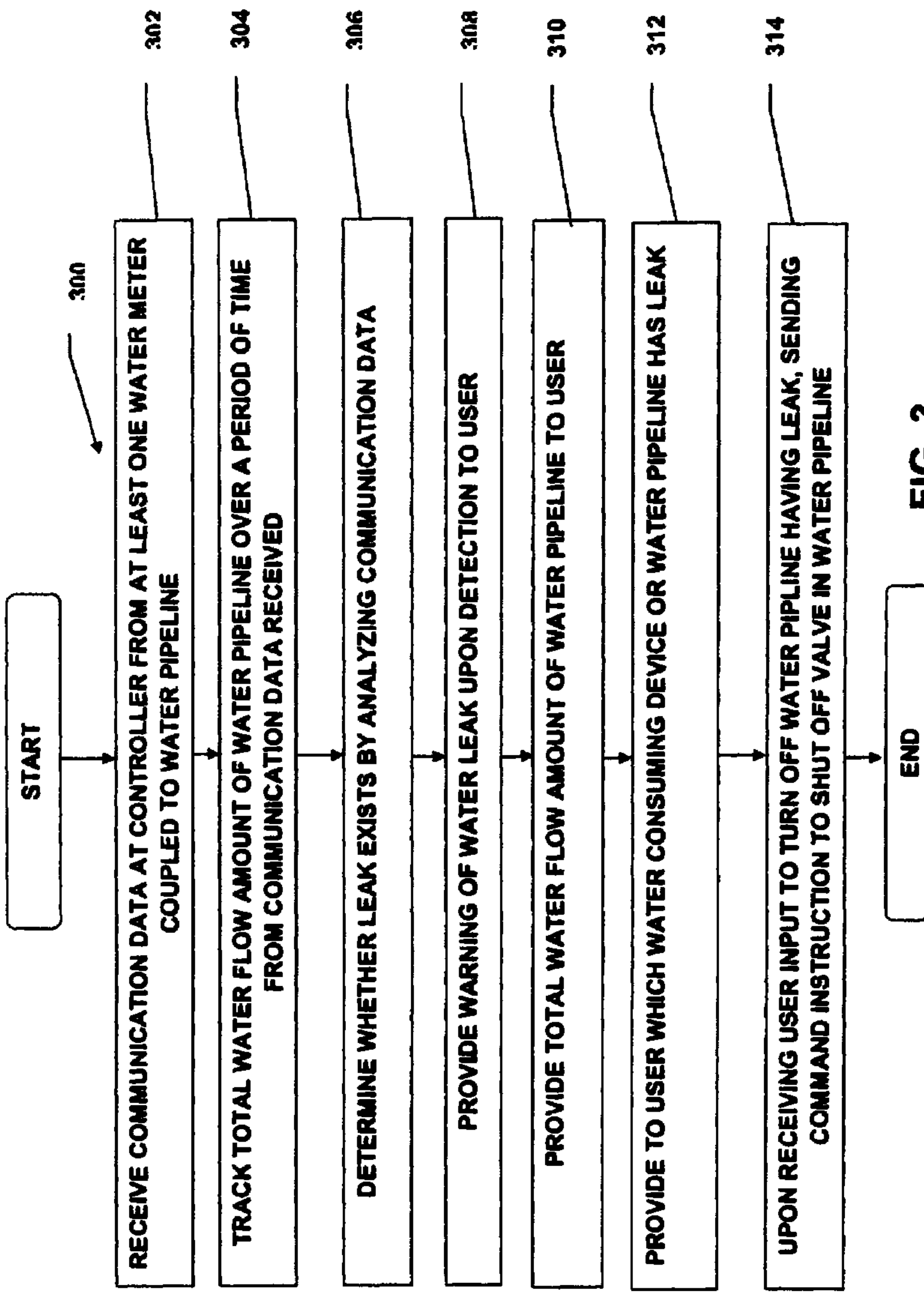

300
START
RECEIVE COMMUNICATION DATA AT CONTROLLER FROM AT LEAST ONE WATER METER COUPLED TO WATER PIPELINE
302
TRACK TOTAL WATER FLOW AMOUNT OF WATER PIPELINE OVER A PERIOD OF TIME FROM COMMUNICATION DATA RECEIVED
304
DETERMINE WHETHER LEAK EXISTS BY ANALYZING COMMUNICATION DATA
306
PROVIDE WARNING OF WATER LEAK UPON DETECTION TO USER
308
PROVIDE TOTAL WATER FLOW AMOUNT OF WATER PIPELINE TO USER
310
PROVIDE TO USER WHICH WATER CONSUMING DEVICE OR WATER PIPELINE HAS LEAK
312
UPON RECEIVING USER INPUT TO TURN OFF WATER PIPLINE HAVING LEAK, SENDING COMMAND INSTRUCTION TO SHUT OFF VALVE IN WATER PIPELINE
314
END

FIG. 3

ENERGY MANAGER—WATER LEAK DETECTION

BACKGROUND

The present disclosure relates generally to methods for monitoring water pipelines and water consuming devices of a home network and systems for operating the same. More particularly, it relates to monitoring water flow of water pipes and detecting leaks therein.

A leaky pipe in a home always occurs at the worst possible moment. The leak may come from any number of devices or pipes in the home. The damage that results varies from no damage at all to major repairs and cost having to be expended. In some instances, water consuming devices in the home have malfunctioned and need to be replaced. When appliances break down that are often part of everyday life, the leak may be quickly noticeable and a fix can be quickly pursued.

For example, water heating storage tanks are used for storing and supplying hot water to households. A typical residential water heater holds about fifty gallons (190 liters) of water inside a steel reservoir tank. A thermostat is used to control the temperature of the water inside the tank. Many water heaters permit a consumer to set the thermostat to a temperature between 90 and 150 degrees Fahrenheit (F) (32 to 65 degrees Celsius (C)). To prevent scalding and to save energy, most consumers set the thermostat to heat the reservoir water to a temperature in a range between 120.0 degrees F. to 140.0 degrees F. (about forty-nine degrees C. to sixty degrees C.). As water heating and storage systems typically have a lifespan of about fifteen to twenty years varying upon the type of system. With age, the possibility of a leak in the pipes to the system increases, which potentially cause damage to the surrounding home structure, such as water through a ceiling. In addition, if a leak is not large enough to be immediately noticeable the efficiency of the water heater is compromised, and thus, a homeowner's water cost, heating and storage efficiency can suffer.

When a leak is present within a pipe, however, the leak may not be as noticeable as water dripping from the ceiling or a flooded basement when a hot water heater has broken down. Various pipes are often interlocked throughout a home to supply a continuous supply of water to many various devices (e.g., refrigerator faucets, washers, etc.). Pipeline leaks have the potential to go unnoticed for longer periods of time, if the leak is small. However, over time an equal or greater amount of damage may ensue. Damage includes loss to structure, foundational shifting, water utility cost increases, increased mold and insect infestation, etc. from a continuous flow of water leaking.

Thus, there is a need for a system that can reduce the amount of damage and cost to homes by quickly identifying leaky pipes or devices spilling water into the home and notifying the owner.

SUMMARY

The present disclosure provides a method for use within an energy management system that alerts the homeowner of a potential water leak. A central controller (e.g., a home energy manager) communicates wired/wireless signals to one or more water meters coupled to a main water pipeline and/or to various water consuming devices, such as a washer, dishwasher, sinks, toilet, etc throughout the home. The water consumption for each device and/or pipeline coupled thereto, and if a value that is out of range of the average is detected or exceeds a predetermined threshold value, the home owner is notified via a system display, a text message, or other communication method about the leak.

In one embodiment, a home network with a central controller includes at least one water meter or flow meter for measuring water that is consumed by a water consuming device. The central controller communicates with the water meter to receive information about the water flow. The central controller tracks a total water flow amount of the water pipeline during a period of time. A leak is determined as existing by comparing the total water flow amount through the pipe over the period of time to a predetermined threshold. If the water flow amount is greater than the expected threshold amount over the period of time, a potential leak has been detected. Upon determining the leak as existing, a warning from the central controller of the home is provided to the user.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is an isometric view of a water monitoring system in accordance with an illustrative embodiment of the present disclosure;

FIG. **2** illustrates water measuring and communication devices in accordance with an illustrative embodiment of the present disclosure; and

FIG. **3** illustrates a flow diagram for monitoring water consumption of a home.

DETAILED DESCRIPTION

Referring to FIG. **1**, illustrated is an exemplary home energy management system **8** for one or more devices **12**, **14** and **16** communicatively linked to a home area network. The devices **12**, **14** and **16** comprise electronic devices, devices that are electronic and water consuming with a water pipeline connected, and devices that are only water consuming without any electronics necessary. For example, the device **12** includes one or more home appliances or processing elements of a home that does not have a water pipeline connected to it and is not a water consuming device. The device **14** includes a water consuming device that is operational with an electronic device control board **26**, (e.g., a dishwasher or refrigerator), and the device **16** comprises one or more water consuming devices, which does not have an electronic control therein, such as a toilet, sink or faucet. For example, the device **14**, and/or **16**, is a water heater, a toilet, a sink, a shower, an outdoor faucet of any kind, a water storage tank, a dishwasher, a refrigerator, any washing machine, and/or any device connected to a water line. The device **12** may also be one or more appliances (e.g., HVAC unit, or other home appliance), or processors, such as a home energy manager or a programmable communicating thermostat, or any other energy consuming devices other than appliances or water consuming devices that are coupled to the home network. The devices within the system **8**, therefore, include both water consuming and electrically operated devices, and combinations thereof.

The home energy management system **8** includes a central controller **10** for managing power consumption and monitoring water consumption within a household. The controller **10** includes a micro processor, which is programmed to selectively send and/or receive signals to a device control board **24** and **26** of devices **12** and **14**, for example, in response to the input signal it receives. The device controllers **24** and **26**, in turn, are operable to manipulate energizing of the power consuming features/functions thereof according to a programming selection.

Within the home management system **8**, the central controller **10** is configured to receive a signal **13** by a receiver and process the signal indicative of one or more energy parameters and/or a utility state of an associated energy supplying utility, for example, including availability and/or current cost of supplied energy. There are several ways to accomplish this communication, including but not limited to power line carrier (PLC) (also known as power line communication), FM, AM SSB, WiFi, ZigBee, Radio Broadcast Data System, 802.11, 802.15.4, etc. The energy signal may be generated by a utility provider, such as a power company or energy provider, and can be transmitted via a power line, as a radio frequency signal, or by any other means for transmitting a signal when the utility provider desires to reduce demand for its resources. The cost can be indicative of the state of the demand for the utility's energy. For example, a relatively high price or cost of supplied energy is typically associated with a peak demand state/period and a relative low price or cost is typically associated with an off-peak demand state/period.

The controller **10** is configured to communicate with, control and/or operate the devices **12** and/or **14** in one of a plurality of operating modes, including at least a normal operating mode and an energy savings mode in response to the received signal. Specifically, the devices **12** and/or **14** can be operated in the normal operating mode during the off-peak demand state or period and can be operated in the energy savings mode during the peak demand state or period. The central controller **10** can be configured to communicate with the devices, in no particular necessary manner or protocol, to precipitate the return of the devices to the normal operating mode after the peak demand period is over. Alternatively, the control board of each appliance could be configured to receive communication directly from the utility, process this input, and in turn, invoke the energy savings modes, without the use of the centralized controller **10**.

The devices **14** and **16**, which are water consuming devices, receive water from a main water inlet pipe **50** for moving water thereto. The main inlet pipe **50**, for example, provides water to all devices of the home that consume water, such as through branch pipelines **60** and **70** that run from the main water inlet pipe **50** to devices **14** and **16** respectively. The device **14** includes the device control board **26**, which communicates through a wired connection or a wireless communication with the central controller **10**. In addition, the branch water pipelines **60** and **70** connected to the devices **14** and **16** are communicatively coupled to the central controller **10** via communication device **66** and **76**, such as through a wired or wireless transmitter device. Water meters or flow meters **62** and **72** are operable to measure an amount of water that flows through the pipelines **60** and **70** and communicate information about the water flow to the controller **10**.

A main water meter **52** is operatively connected to the main water inlet pipe **50** for measuring a total amount of water flow into the home and communicating information gathered to the controller **10** via a communication module **56**. For example, the central controller **10** receives information from the flow meters **52**, **62** and **72** on the total amount of water flowing through pipelines **50**, **60**, and **70** respectively over a period of time, such as in about an hour or less, for example. Each hour or in less time, therefore, the central controller **10** determines the water flow going through the pipe to determine if a leak condition exists in the pipe or device connected thereto. If the water flow exceeds a certain predetermine threshold amount, a leak is determined as existing. The predetermined threshold for determining the presence of a leak may be different for different devices and based on the amount of use a device gets over a period of time, as well as by other factors. For example, whether a water flow is continuous for an extended period of time or sporadic may also be factored into the determination. In addition, if a water flow in the pipe is excessive, a leak may be determined once a certain amount has been exceeded for a given period of time, so that if the pipe is connected to a shower device for bathing, for example, a leak would not be determined until more than an expected amount of water flows through the pipe. This threshold amount is variable depending upon the type of water consuming device. In one embodiment, the predetermined threshold may be an average amount of water based on historical use of the water consuming device with allowance for a standard deviation, for example.

In one example, a typical flow rate of a showerhead is ~2 gal/min. The homeowner could easily time the length of a typical shower. Assuming his/her average shower length is 12 minutes, this would result in the flow meter measuring 24 gallons over the 12 minutes. The user could then set the predetermined threshold value to 30 gal. If the controller ever saw **30** plus gallons being consumed over 15 minutes, then it could notify the homeowner of a possible leak.

In addition, another option would be for the controller to learn this behavior by monitoring the flow meter over the course of days/weeks. Once it learns the max value that is consumed over a given length of time it could add a buffer, to avoid the nuisance trips, and set this value as the predetermined threshold.

Another example of detecting unintended water usage involves monitoring usage by toilets which occasionally leak in the sense of failing to fully terminate the fill operation after being flushed. A typical toilet holds between 1 and **4** gallons of water. It typically takes 1-2 minutes for a toilet to refill after being flushed. In order to detect such a leak while allowing for back-to-back flushes, a threshold could be set on the order of 10 gallons over a 5 minute period. If the controller detects **10** plus gallons being consumed over 5 minutes it could notify the homeowner of a possible leak.

The controller **10** includes a user interface **20** having a display **22** and control buttons for making various operational selections. The display can be configured to provide active, real-time feedback to the user on the cost of operating each device **12**, **14**, **16**, as well as water consumption information for the water consuming devices **14** and **16**. The costs are generally based on the current operating and usage patterns and energy consumption costs, such as the cost per kilowatt-hour charged by the corresponding utility or a cost per gallon of water, for example. The controller **10** is configured to gather information and data related to current usage patterns and as well as current power costs, and generate historical usage charts therefrom. This information can be used to determine current energy usage and cost associated with using each device and in each mode an electronic device may be in. This real-time information (i.e., current usage patterns, current power cost, current energy usage/cost and water consumption) can be presented to the user via the display.

In one exemplary embodiment, the controller **10** connects via either Ethernet or WiFi to the homeowner's router and to a client application **34**, for example, in a personal computer **36** and/or a mobile device **38**. The controller **10** also has the ability to periodically transmit data to a central server on the Internet **40**. This allows for remote service and monitoring capability. A server **42** can keep records of all homes therein that may be accessed remotely via the Internet.

In another embodiment, the total amounts of water flow through the pipelines **50**, **60** and **70** are provided to the user, such as in the user display **22**. In addition, a warning message can be sent to a user or homeowner about a leak that has been

detected within one of the pipelines. For example, if a water flow in pipeline 70 is determined to have a leak, then a text message, email, and/or a user display message may be transmitted via the internet or on the user display 22 to inform the homeowner of a leak. Where multiple meters are placed at the main water inlet pipe 50 with meter 52 and at branch pipelines 60 and/or 70, the location of the leak or the device, which is the cause or source of the leak, can also be communicated in a message to the user.

In another embodiment, the system 8 includes shut off valves 58, 68, and 78 at respective pipelines 50, 60 and 70. The central controller 10 may receive input from the user or homeowner in response to the warning or message, and the user, for example, may respond with instructions to shut off the pipelines 50, 60, and/or 70 via the respective shut off valve 58, 68 and 78. In this manner, leaks are detected within a home and homeowners are informed of the conditions in which the water consuming devices operate. Informed decisions regarding water usage are made by the homeowner and potentially catastrophic water destruction in a home is more easily avoided. The user also has control over the water flow by enabling a shut off of any particular pipeline, such as to the whole home through the main pipeline 50 or at branch pipelines 60 and/or 70.

For example, FIG. 2 illustrates an example of a measuring device, such as a flow meter 216 for measuring the amount of water used by various types of water consuming devices. A central controller of a home network communicates wirelessly, for example, to radios that are connected to various sensors. There are several ways to accomplish this communication, including but not limited to power line carrier (PLC) (also known as power line communication), FM, AM SSB, WiFi, ZigBee, Radio Broadcast Data System, 802.11, 802.15.4, etc. The controller of FIG. 1 may communicate directly therefore via a wired, optical and/or wireless connection, and the present disclosure is not limited to any one specific method for communicating.

Different natural resources may be monitored by the central controller 10. For example, water measurement may be monitored where the system includes a water meter 216 and a communication module that is a wireless radio module 218, for example. The water meter 216 is inserted into the home's incoming water line 220. The water meter 216 gives an output for each gal/liter/etc. of water consumed, for example, over or during a period of time. This output is sent to the radio module 218 that in turn sends the information back to the central controller 10. In one embodiment, the water utility can directly send the consumption data to the central device controller 10 via any available means, including 802.15.4 Zigbee, the Internet or IP connection 40.

Local utility and rate information is also broadcast at blocks 234 from the utility or energy provider to the controller 10 directly. The controller 10 can receive rate and schedule information as well as demand side management DSM signals to pass them on to the household appliances, such as devices 232.

The devices 232 may also transmit energy/power consumption, as well as water consumption information to the central controller 10. Referring back to FIG. 1, the controller 10 further comprises a memory 30 having at least table 32 that collects water consumption data, energy consumption, generation and/or storage data for a home or other structure (e.g., warehouse, business, etc.). The table may additionally comprise variables associated with the heating and cooling conditions of the home, for example. A table is generated for each monitored device that includes historical home data and data that is currently updated, which may be used in a client application running on a device, such as a computer or mobile phone, for presenting graphs or other data to the user.

The operation of each device 12 and/or 14 may vary as a function of a characteristic of the utility state and/or supplied energy. Because some energy suppliers offer time-of-day pricing in their tariffs, price points could be tied directly to the tariff structure for the energy supplier. If real time pricing is offered by the energy supplier serving the site, this variance could be utilized to generate savings and reduce chain demand.

Building on the ability of the central controller to periodically upload data to a central server, the system 8 has the capability for the homeowner to log onto a secure web portal and view data from their home. This will allow consumers additional flexibility to monitor their home while away.

Example methodology 300 for monitoring a home for a leak is illustrated in FIG. 3. While the methods are illustrated and described below as a series of acts or events, it will be appreciated that the illustrated ordering of such acts or events are not to be interpreted in a limiting sense. For example, some acts may occur in different orders and/or concurrently with other acts or events apart from those illustrated and/or described herein. In addition, not all illustrated acts may be required to implement one or more aspects or embodiments of the description herein. Further, one or more of the acts depicted herein may be carried out in one or more separate acts and/or phases.

The method 300 of FIG. 3 allows monitoring of pipelines and/or water consuming devices connected to the pipelines for a leak. The method is provided for a home network at a home that includes at least one water meter for measuring water consumed by water consuming devices within the network. A central controller is communicatively linked to the water meter and includes a memory storing executable instructions for the method. The method begins at start and at 302 a communication is received by the central controller from at least one water meter, which is operatively coupled to a water pipeline for measuring water flow. The water meter can be a flow meter that is inserted in the water line or some other measuring device coupled the water pipe of a home capable of measuring water amounts or water flow amounts in a pipeline. The water pipelines include a main water pipeline and branch pipelines connected to the main pipeline and water consuming devices. Communications are received by the controller for more than one water pipeline and from more than one meter for tracking individual water pipelines and water consuming devices connected thereto. The flow meter at each pipeline, for example, has a communication module connected that wirelessly or in a wired fashion transmits communication data to the controller.

At 304 the controller tracks the information received, such as by storing the information in a memory, and over a period of time the data can be used to calculate a total water flow amount going through the pipeline. A water flow rate, an average water amount, a total water amount, for example, can be calculated by the flow meter. The period of time may vary and could be about sixty minutes or less, for example. Other increments of time are also possible.

At 306 whether a leak exists within the pipelines of the home is determined by analyzing the data received. For example, a total water flow amount over the period of time may be compared to a predetermined amount, which is a maximum threshold designated for the pipeline or may be an average amount with a standard deviation limit set. If the total water flow amount exceeds the predetermined threshold, then a leak is determined as present, for example. At 308 a warning is provided to the homeowner or user, which may be via an

internet connection of the home network, via text, email, and/or on a user display at the home. Any means of communication is foreseeable and not outside the scope of this disclosure. At **310** the total water flow amount and/or other measurements gathered regarding the water in the pipelines may be also provided to the user. This can enable better and informed decisions for conserving water at the home. At **312** where the leak is present is determined and the user is provided the particular water consuming device or water pipeline that is experiencing the leak.

At **314** the network may receive a response from the user to shut off different pipelines or the main water inlet pipeline to the home via shut off valve. The controller sends information to the meter for controlling the valve. In one example, a solenoid device may be used for operating the shut off valve and sealing off the pipeline where the leak exists or the main water line pipe to the home.

The invention has been described with reference to the preferred embodiments. Obviously, modifications and alterations will occur to others upon reading and understanding the preceding detailed description. It is intended that the invention be construed as including all such modifications and alterations.

What is claimed is:

1. A method for monitoring a home for a leak within a home network that includes a water meter for measuring water consumption within the home network and a central controller communicatively linked to the water meter, the central controller including at least one memory for storing executable instructions, the method comprising:

tracking a total water flow to a water consuming device for a period of time;

identifying a maximum amount of the total water flow to the water consuming device that occurs during a subinterval length of time in the period of time;

assigning the maximum amount to a threshold value;

receiving communication data at the central controller, the communication data reflecting a total water flow amount from a water pipeline that is operatively coupled to the water meter;

tracking the total water flow amount of the water pipeline over the subinterval length of time from the water meter;

analyzing the total water flow amount by comparing the total water flow amount to the threshold value; and

generating an output to an end user that alerts the end user of a leak when the total water flow amount exceeds the threshold value for the subinterval length of time.

2. The method of claim **1**, wherein the water pipeline comprises a main pipeline having a plurality of branch pipelines coupled thereto, wherein the plurality of branch pipelines provide water to different water consuming devices.

3. The method of claim **1**, wherein the water consuming device includes one of a toilet, a sink, a shower, an outdoor faucet, a washing machine, a dishwasher, a refrigerator, a water storage device, and home device having a secondary pipeline connected to the water pipeline.

4. The method of claim **1**, wherein the subinterval length of time is less than about sixty minutes.

5. The method of claim **2**, further comprising identifying the water consuming device or the branch water pipeline in which the leak is located.

6. The method of claim **5**, wherein the output comprises a communication message that identifies which water consuming device or water pipeline has the leak.

7. The method of claim **1**, wherein the output comprises a warning from the central device to the end user upon detecting the leak via at least one of a text message, an email, a phone message, and a user interface display operatively coupled to the controller.

8. A method for monitoring a home for a leak within a home network that includes a plurality of water flow meters for measuring water being consumed by water consuming devices within the network and a central controller communicatively linked to the water meters and the water consuming devices, the controller including at least one memory for storing executable instructions, said method comprising:

tracking a total water flow amount for each water pipeline of a plurality of water pipelines respectively coupled to a plurality of water consuming devices within the home network over a period of time;

identifying a maximum amount of the total water flow to the water consuming device that occurs during a subinterval length of time in the period of time;

assigning the maximum amount to a threshold value; and

determining whether a leak exists at the home by comparing the total water flow amount of each water pipeline to the threshold value set for each of the water consuming devices.

9. The method of claim **8**, further comprising identifying the particular water consuming device and/or water pipeline in which the leak exists, wherein water pipelines of the plurality of water pipelines respectively have a different threshold value for determining whether the leak exists.

10. The method of claim **9**, further comprising providing a warning from the central controller to an end user of the home to indicate that the leak exists and from which water consuming device and/or water pipeline the leak originates.

11. The method of claim **8**, wherein each water pipeline is operatively coupled to at least one of the flow meters that measure the total water flow amount incoming to the home and to each water consuming device.

12. The method of claim **11**, further comprising receiving communications data at the central controller from the flow meters via a wireless transmitter, wherein the communications data indicates a total water flow amount for each water pipeline and/or a total water flow amount for the home.

13. The method of claim **10**, further comprising receiving an input from the user indicating whether to turn the water pipeline with the leak off; and in response to the input, sending a communication command to trigger a shut off valve to stop water flow in the water pipeline.

14. An energy management system for a home network comprising water consuming devices coupled to water inlets at a home, said energy management system comprising:

a central controller comprising a processor and memory for storing executable instructions;

a water flow meter coupled to a water pipeline for each of the water consuming devices, wherein the water flow meter is configured to measure a total water flow amount in the water pipeline;

a communication device coupled to the flow meter, the communication device configured to communicate the total water flow amount to the central controller; and

a user device display operatively connected to the central controller that provides the total water flow amount to an end user,

wherein the executable instructions include instructions for:

tracking the total water flow amount to the water consuming device over a period of time;

identifying a maximum amount of the total water flow to the water consuming device that occurs during a subinterval length of time in the period of time;

assigning the maximum amount to a threshold value; and

determining whether a leak exists at the home by comparing the total water flow amount of each water pipeline to the threshold value set for each of the water consuming device.

15. The system of claim **14**, wherein the central controller is configured to provide a warning to the end user that a leak exists in the water pipeline based on the total water flow amount exceeding the threshold value over the subinterval length time.

16. The system of claim **14**, further comprising a shut off valve located at the water pipeline to shut off water flow therein upon the controller receiving an input from the end user to shut off the water pipeline.

17. The system of claim **14**, wherein the at least one water pipeline is a main water pipeline that provides water to the home and the water consuming devices.

18. The system of claim **14**, wherein the water consuming devices include one of a toilet, a sink, a shower, an outdoor faucet, a washing machine, a dishwasher, a refrigerator, a water storage device and home device having the secondary pipeline connected to the main water pipeline.

* * * * *

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(54) **VALVE METER ASSEMBLY AND METHOD**

(75) Inventors: **Marty Scott Ball**, Jonesville, NC (US); **Scott Aron Linkel**, Kannapolis, NC (US)

(73) Assignee: **Mueller International, LLC**, Atlanta, GA (US)

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See application file for complete search history.

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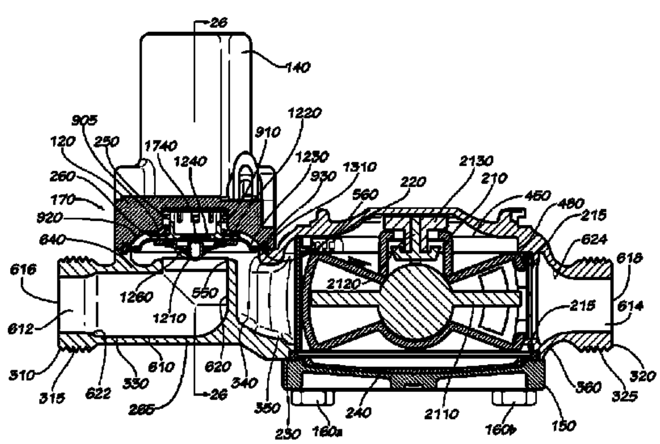
Primary Examiner — John Rivell
(74) *Attorney, Agent, or Firm* — Taylor English Duma LLP

(57) **ABSTRACT**

A valve meter device, assembly, and method is disclosed including a housing defining at least one inlet opening and at least one outlet opening and a channel connecting the openings, the at least one inlet opening having an inlet end and the at least one outlet opening having an outlet end; a water meter positioned in the channel, the water meter configured to monitor a flow of water through the valve meter device; and a valve in communication with the channel and configured to control the flow of water through the valve meter device. In some embodiments, a linear distance exists between the inlet end and the outlet end, the linear distance being no greater than a standard water meter lay-length.

20 Claims, 25 Drawing Sheets



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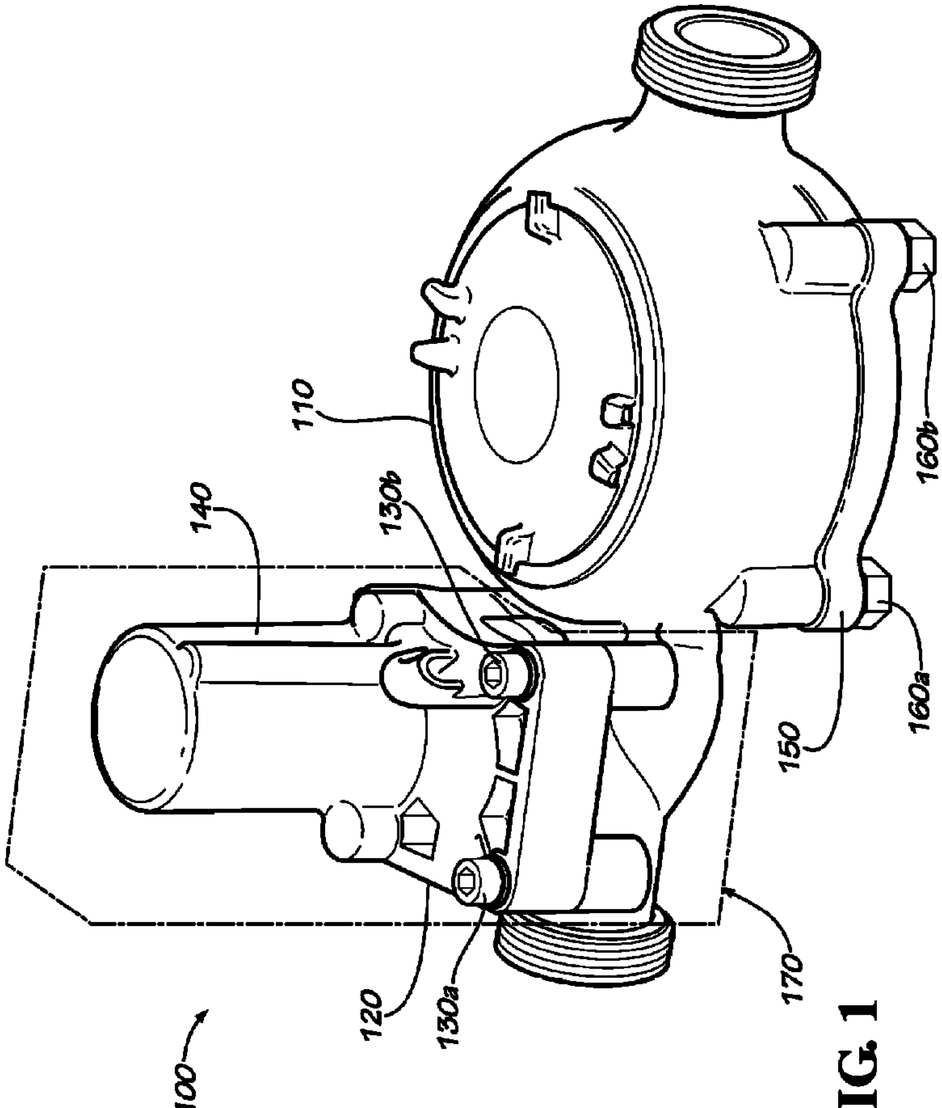

FIG. 1

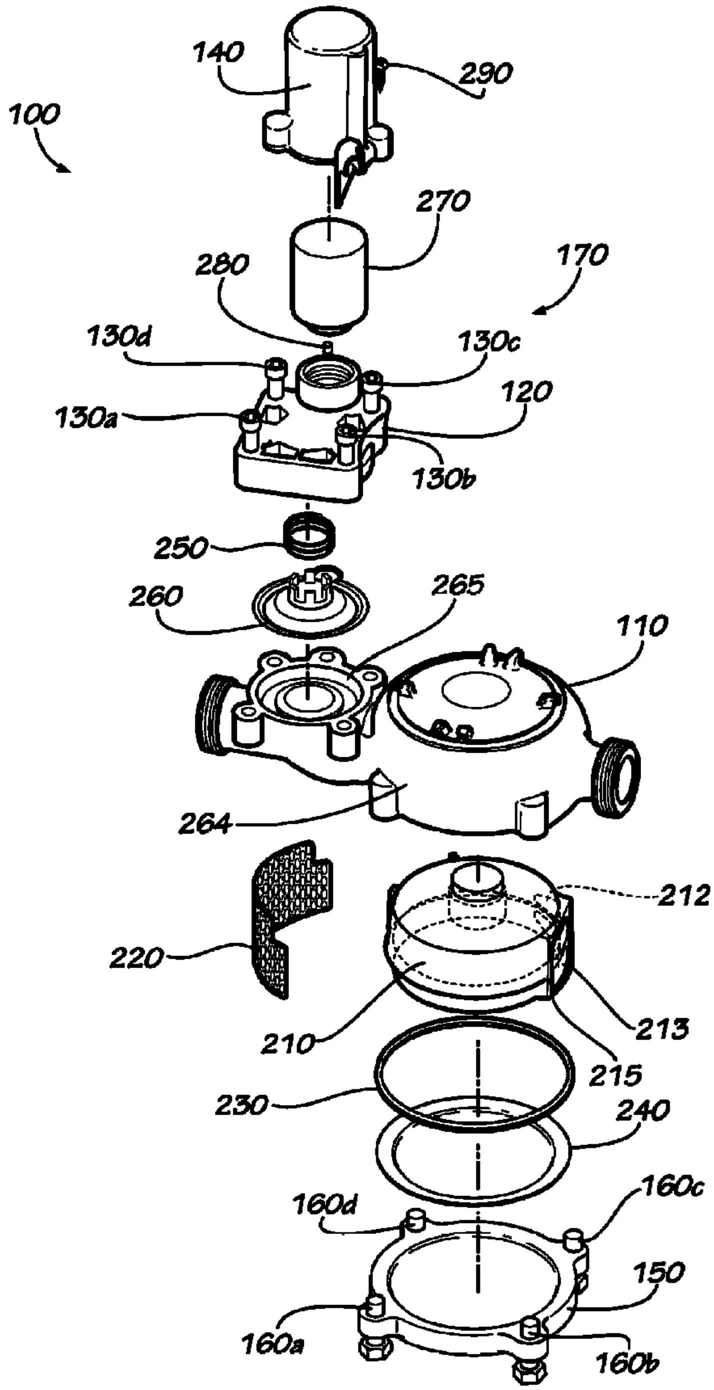
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FIG. 2

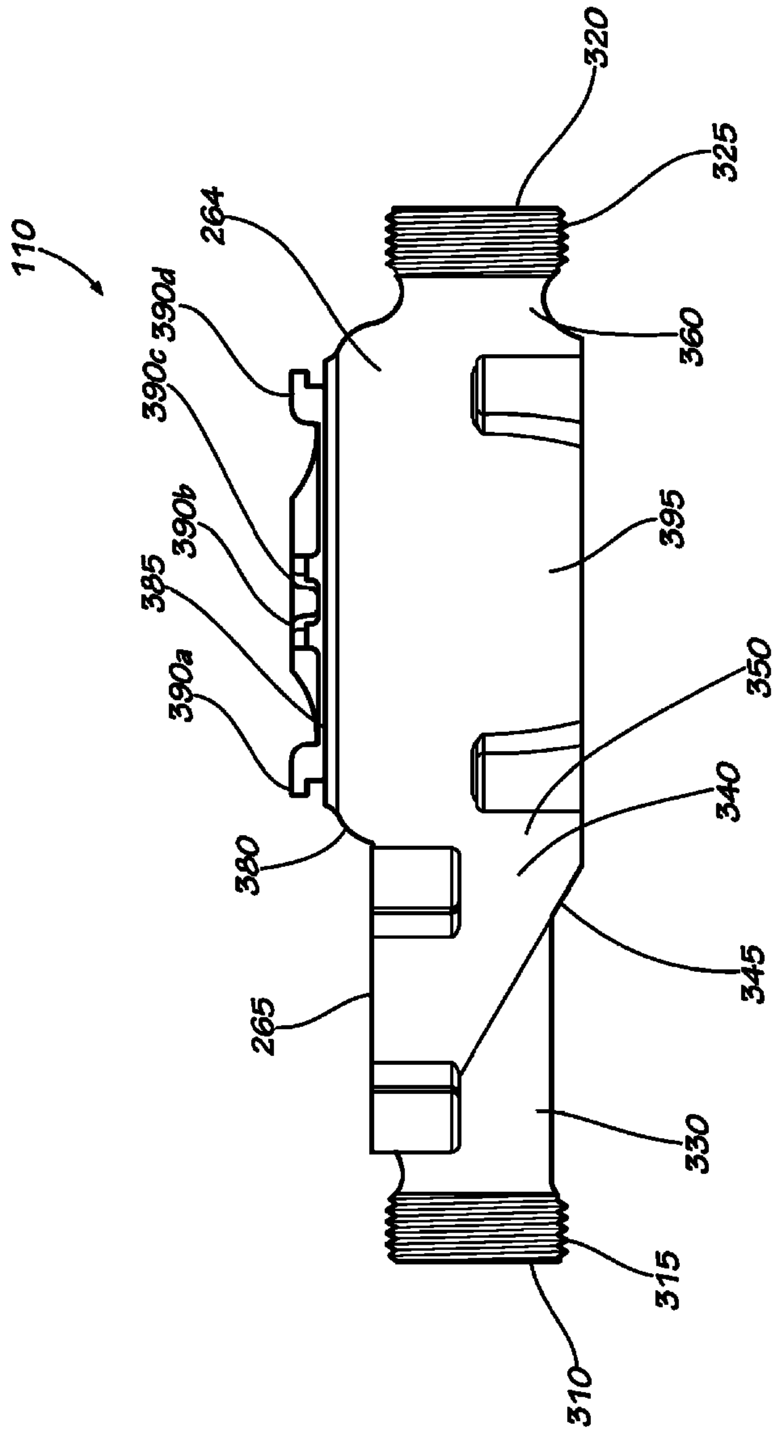
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FIG. 3

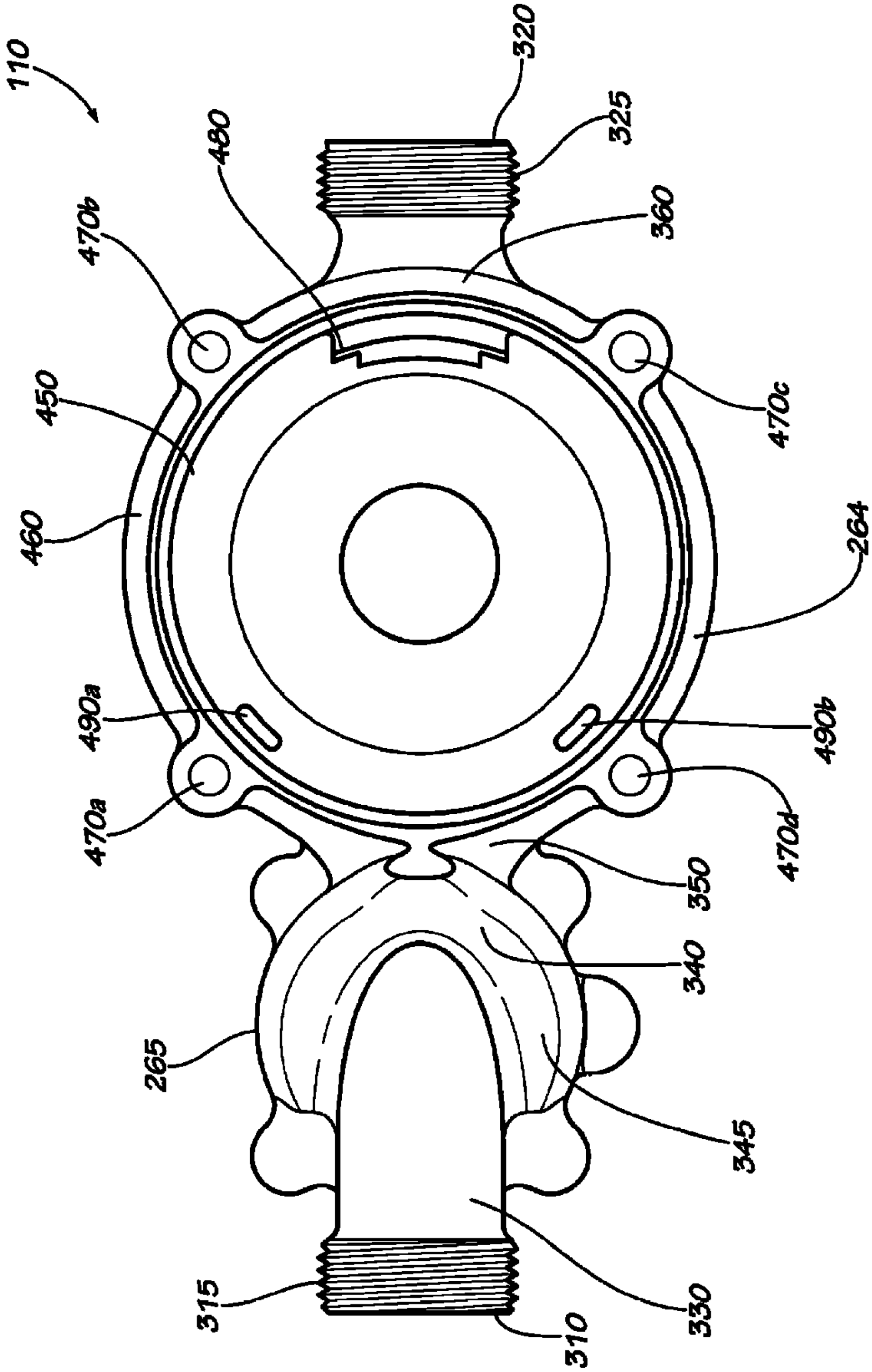
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FIG. 4

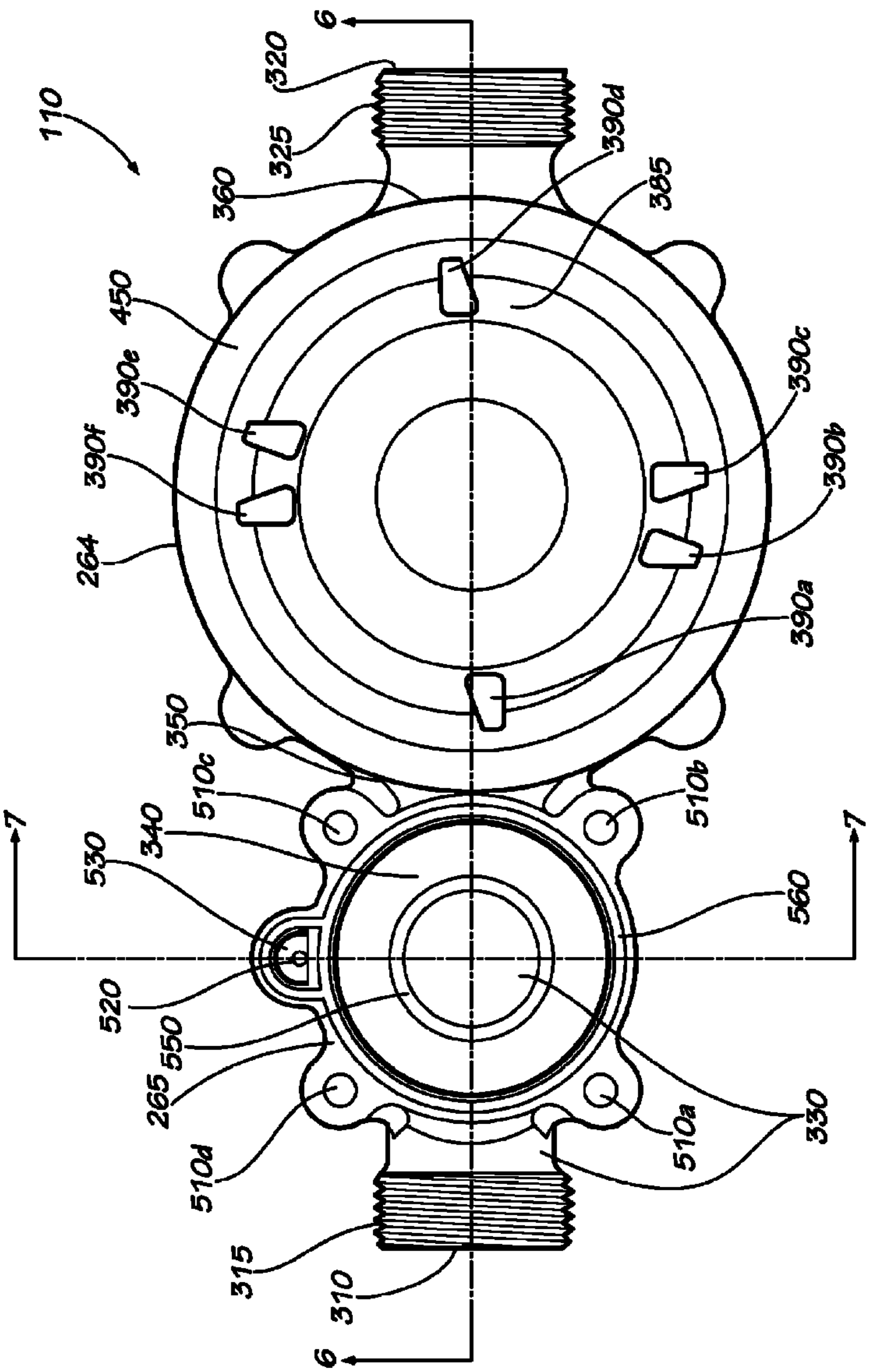
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FIG. 5

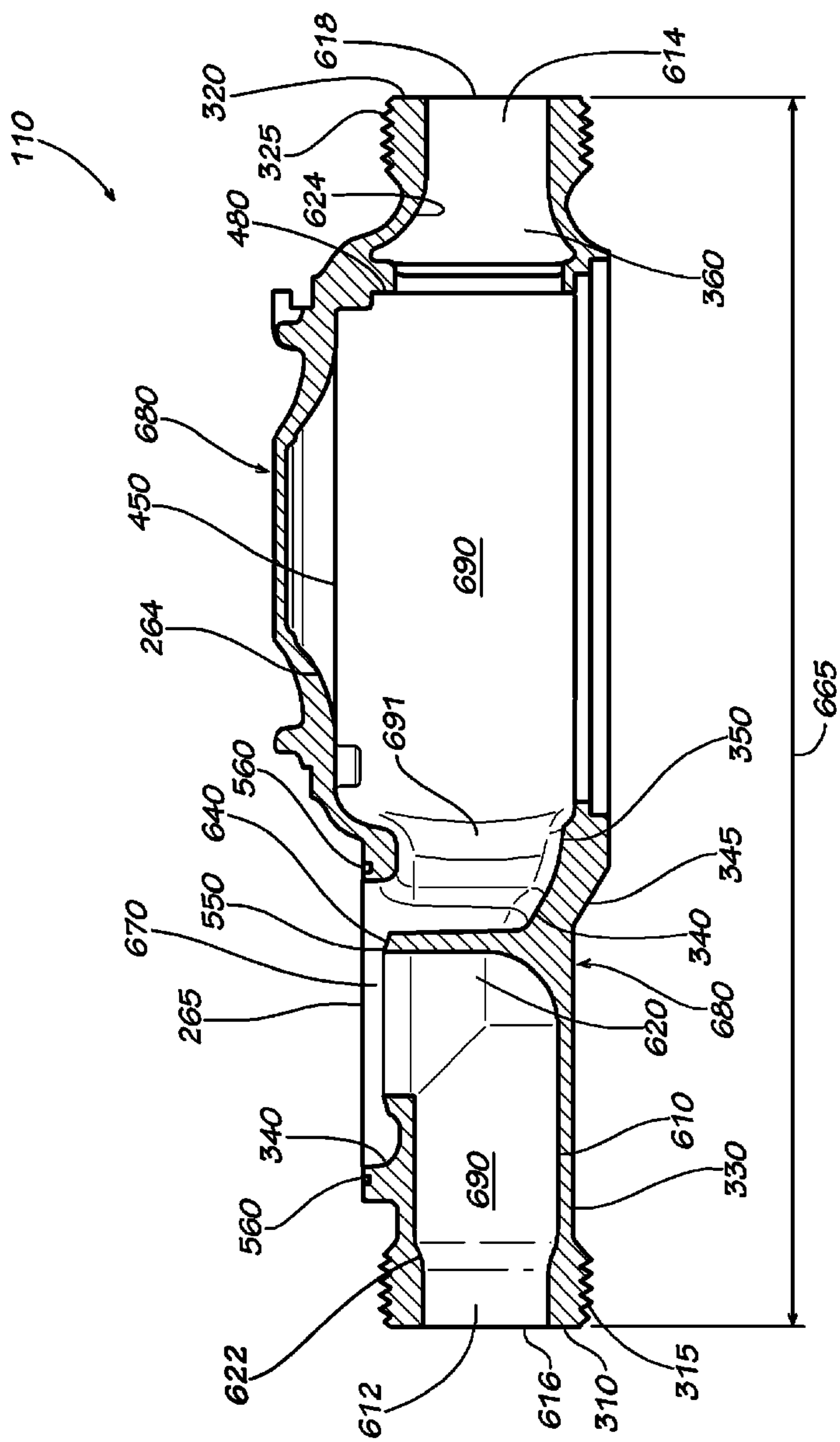
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FIG. 6

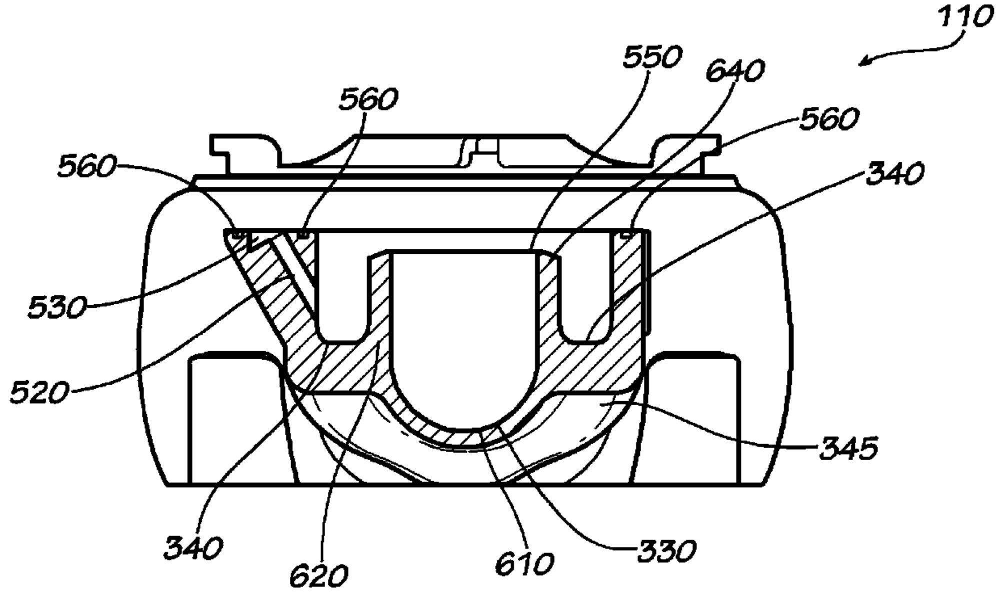
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FIG. 7

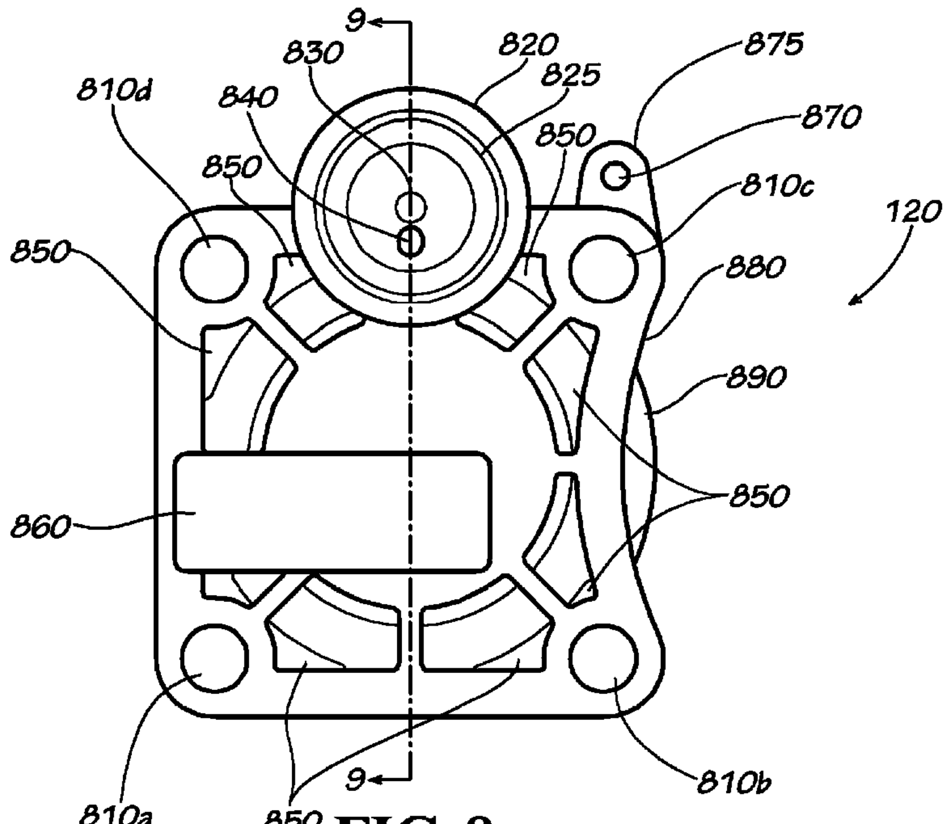
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FIG. 8

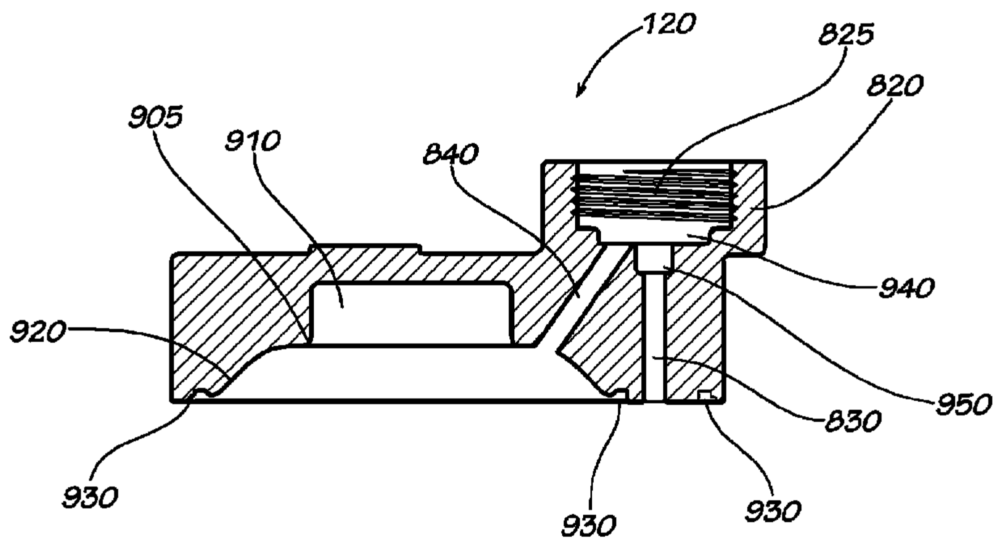
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FIG. 9

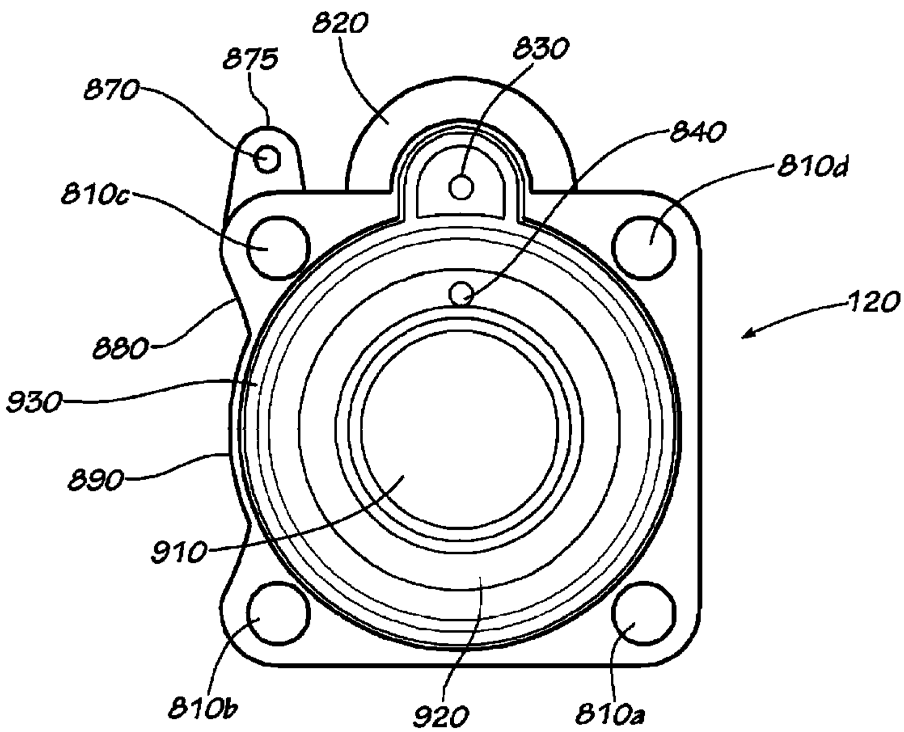
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FIG. 10

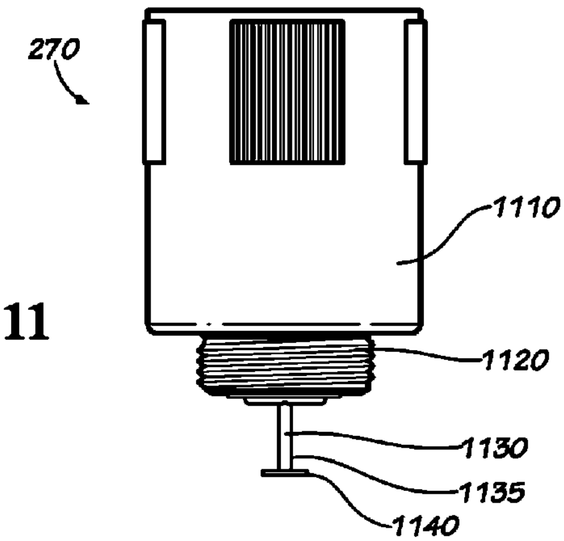
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FIG. 11

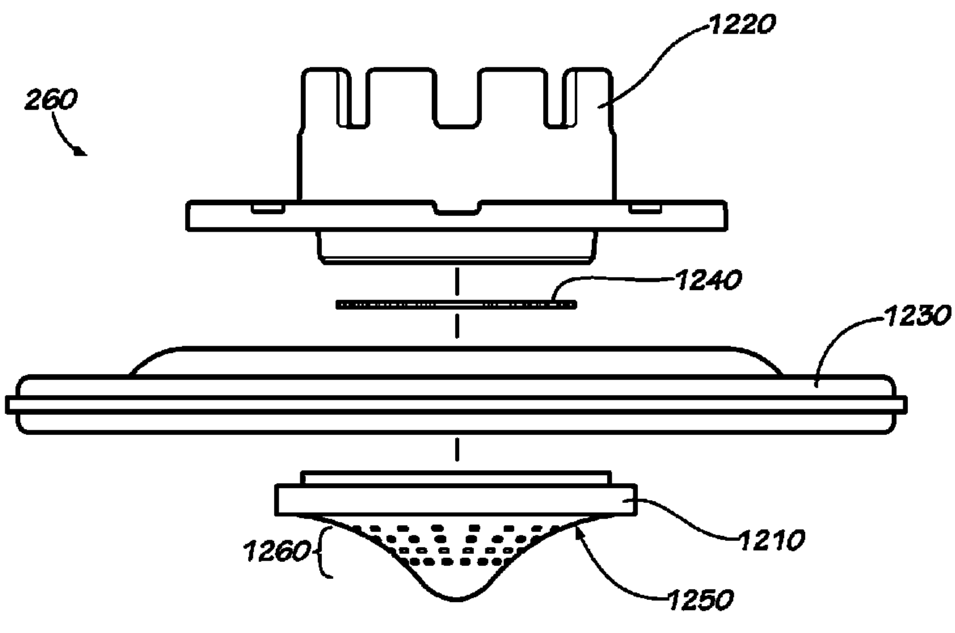
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FIG. 12

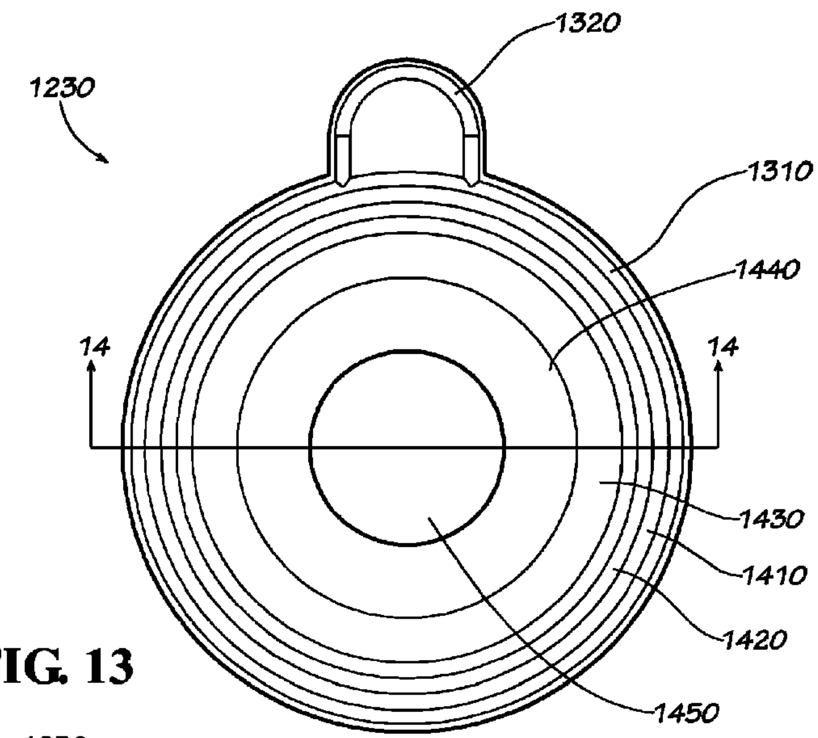
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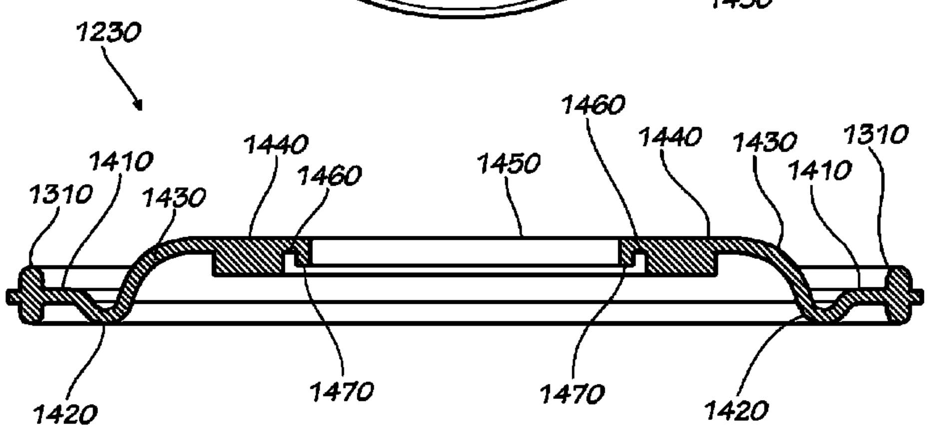
FIG. 13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1410
1440
1460
1450
1310
1430
1410
1420
1470
1470
1420

FIG. 14

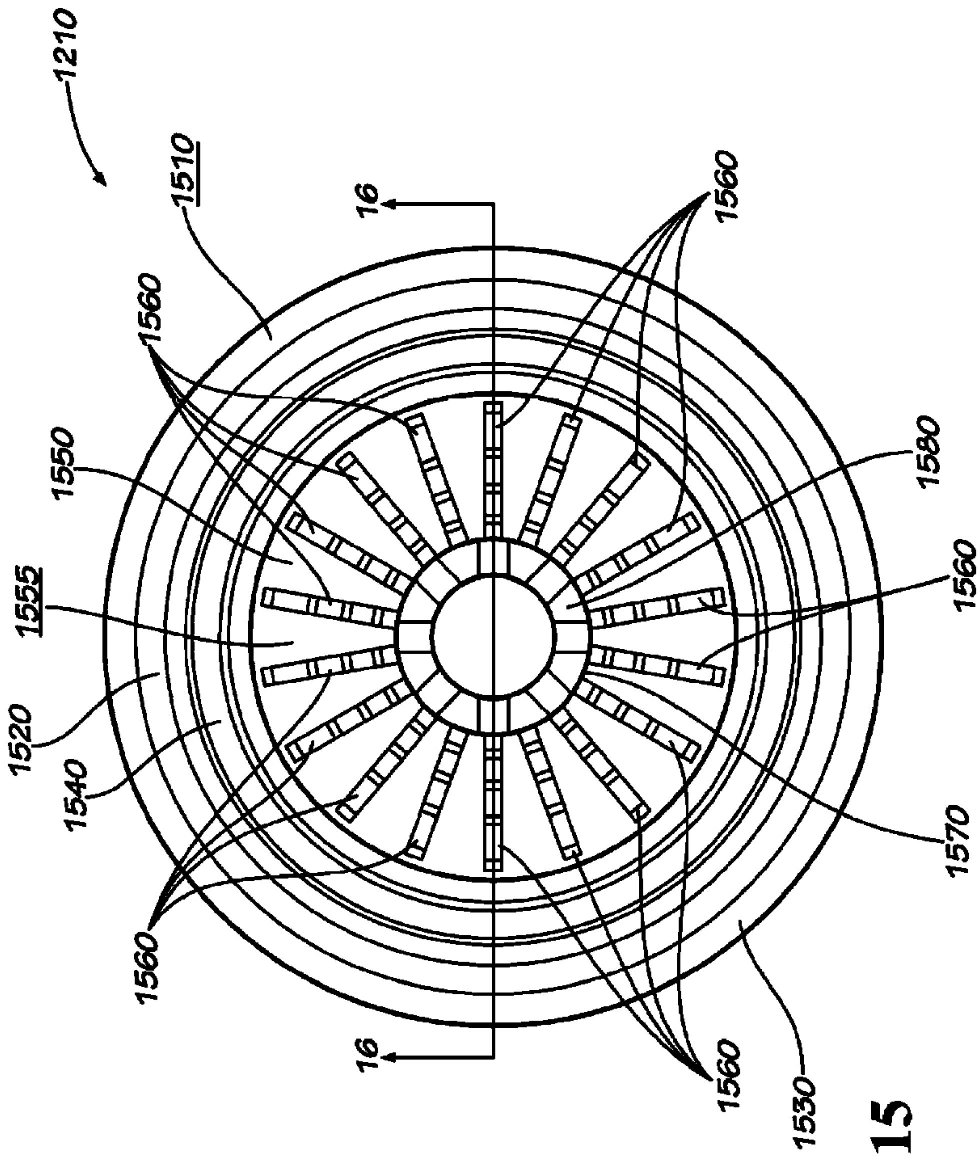

FIG. 15

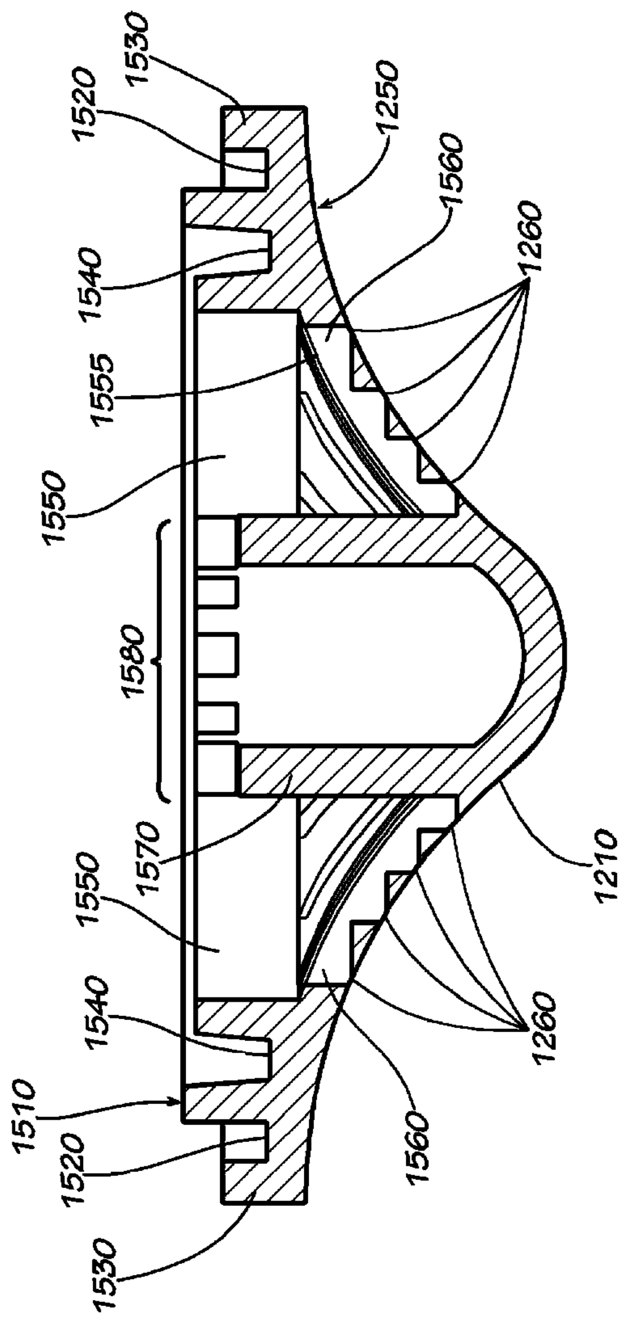
1530
1520
1250
1560
1260
1540
1555
1550
1580
1570
1550
1540
1510
1520
1530
1560
1260
1210

FIG. 16

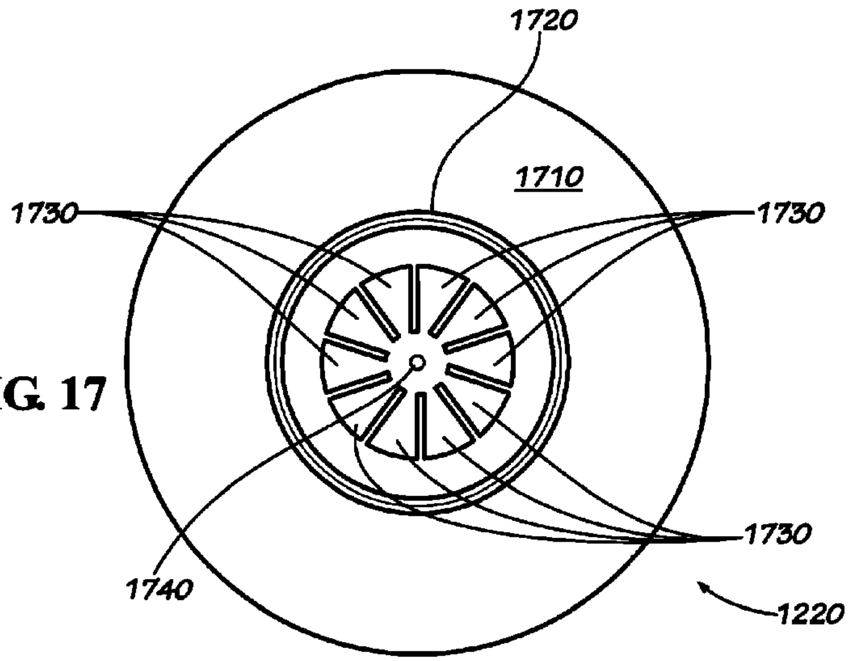
1720
1710
1730
1730
1730
1740
1220

FIG. 17

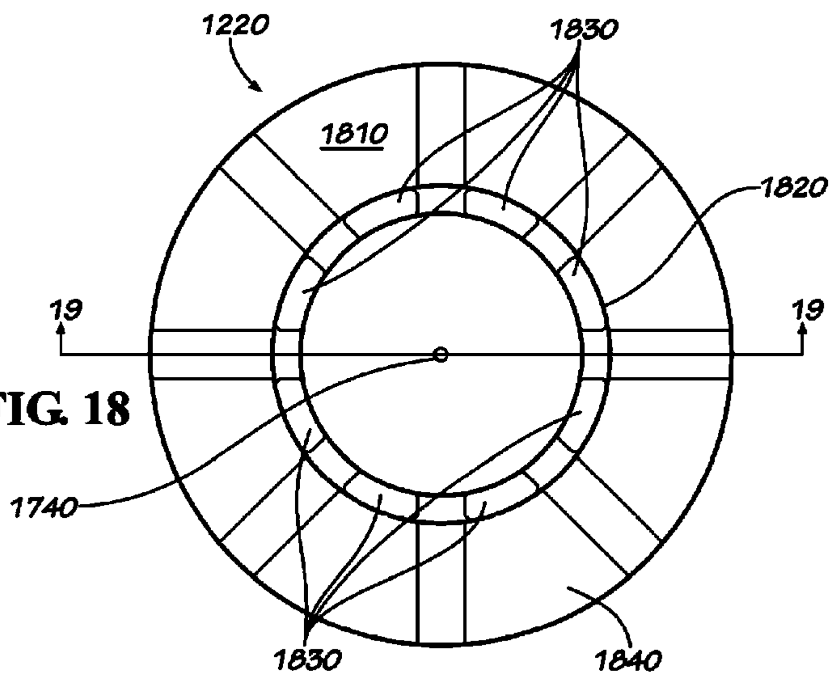
1220
1830
1810
1820
19
19
1740
1830
1840

FIG. 18

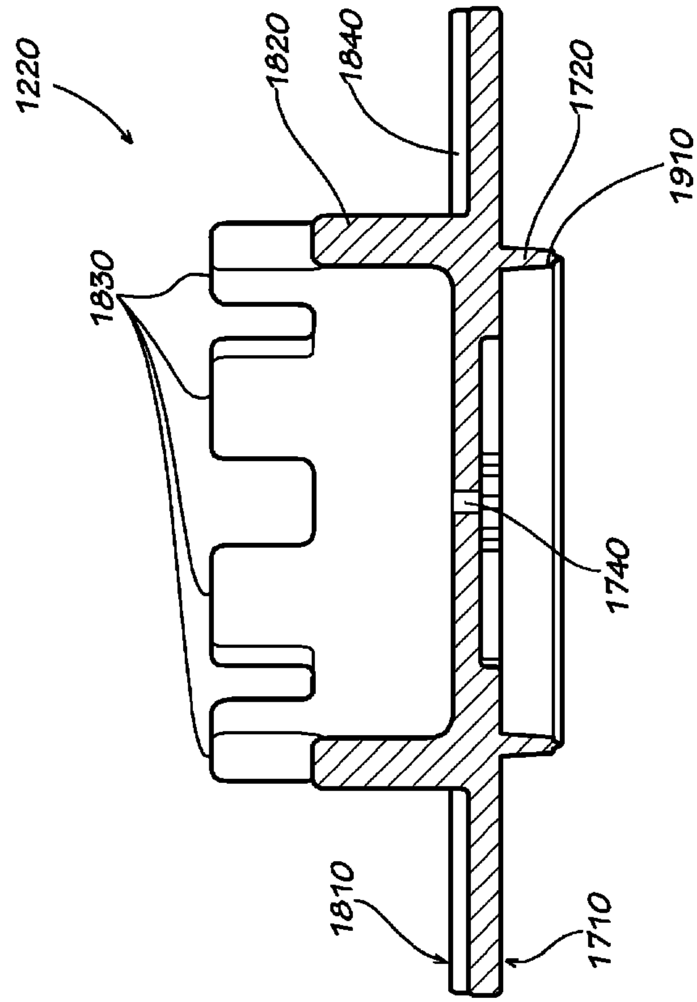

FIG. 19

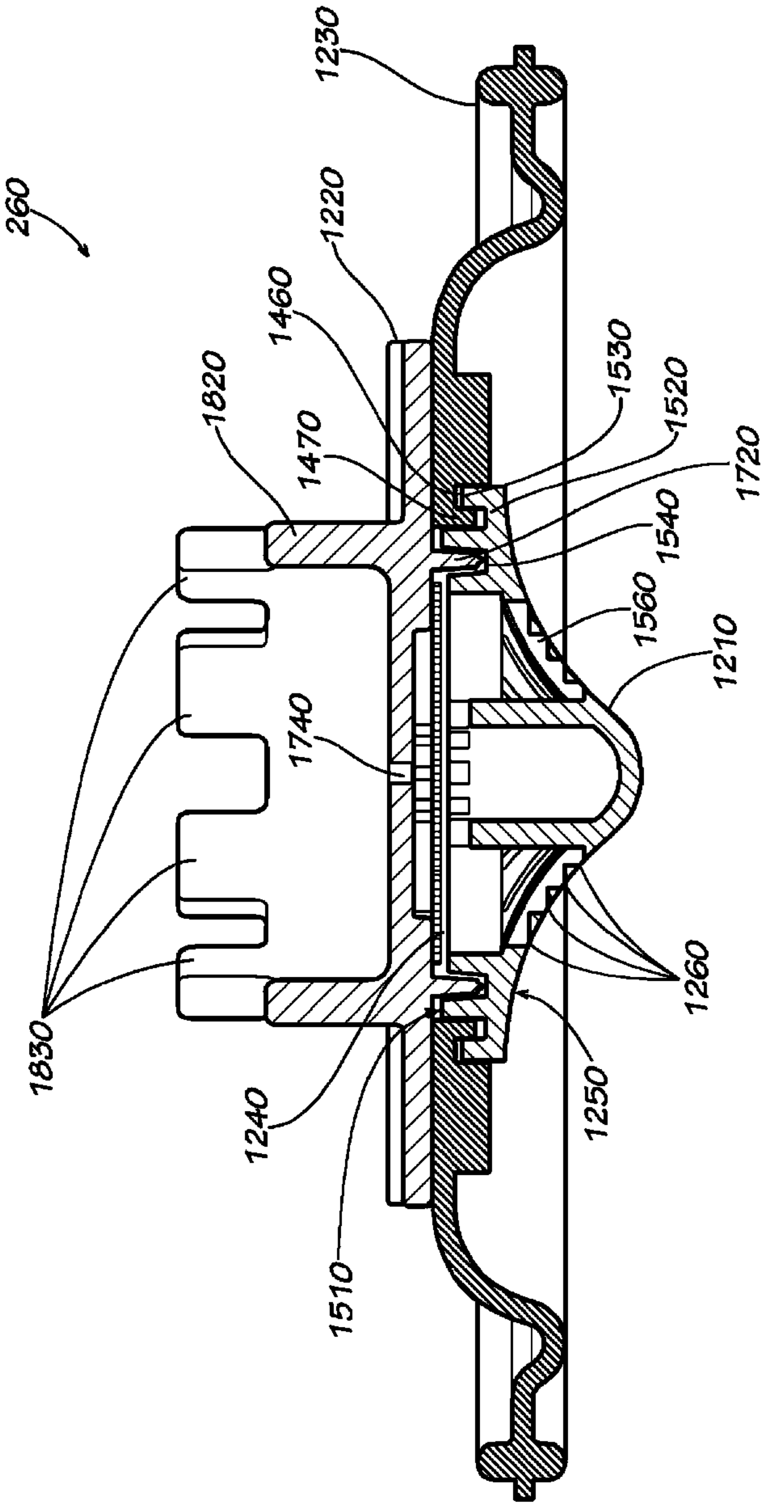
260
1230
1220
1460
1820
1470
1530
1520
1720
1540
1560
1210
1740
1830
1240
1250
1260
1510

FIG. 20

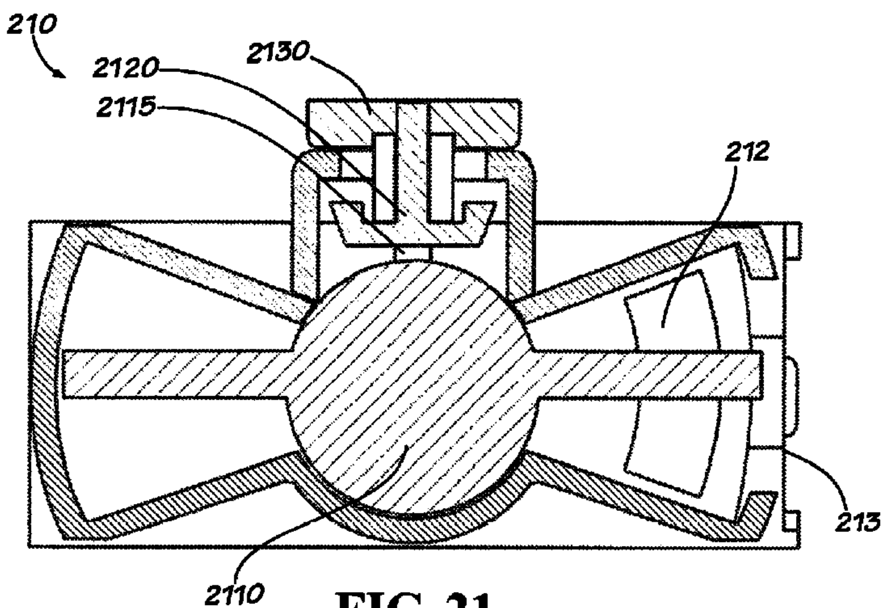

FIG. 21

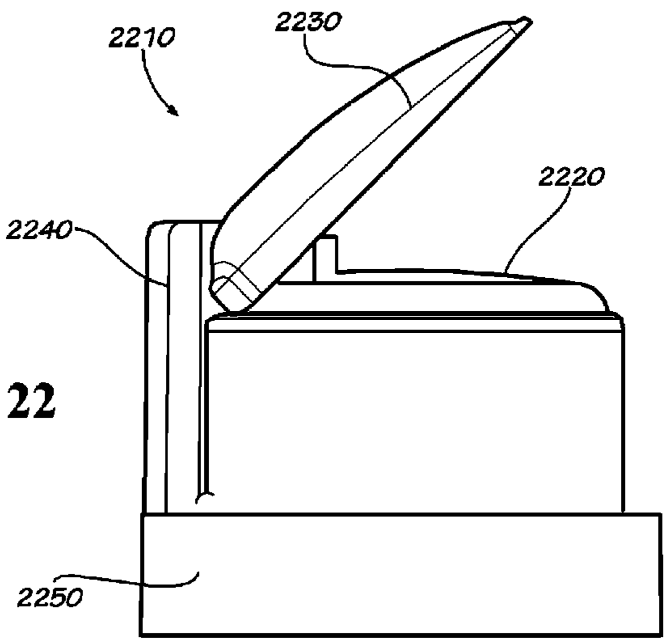

FIG. 22

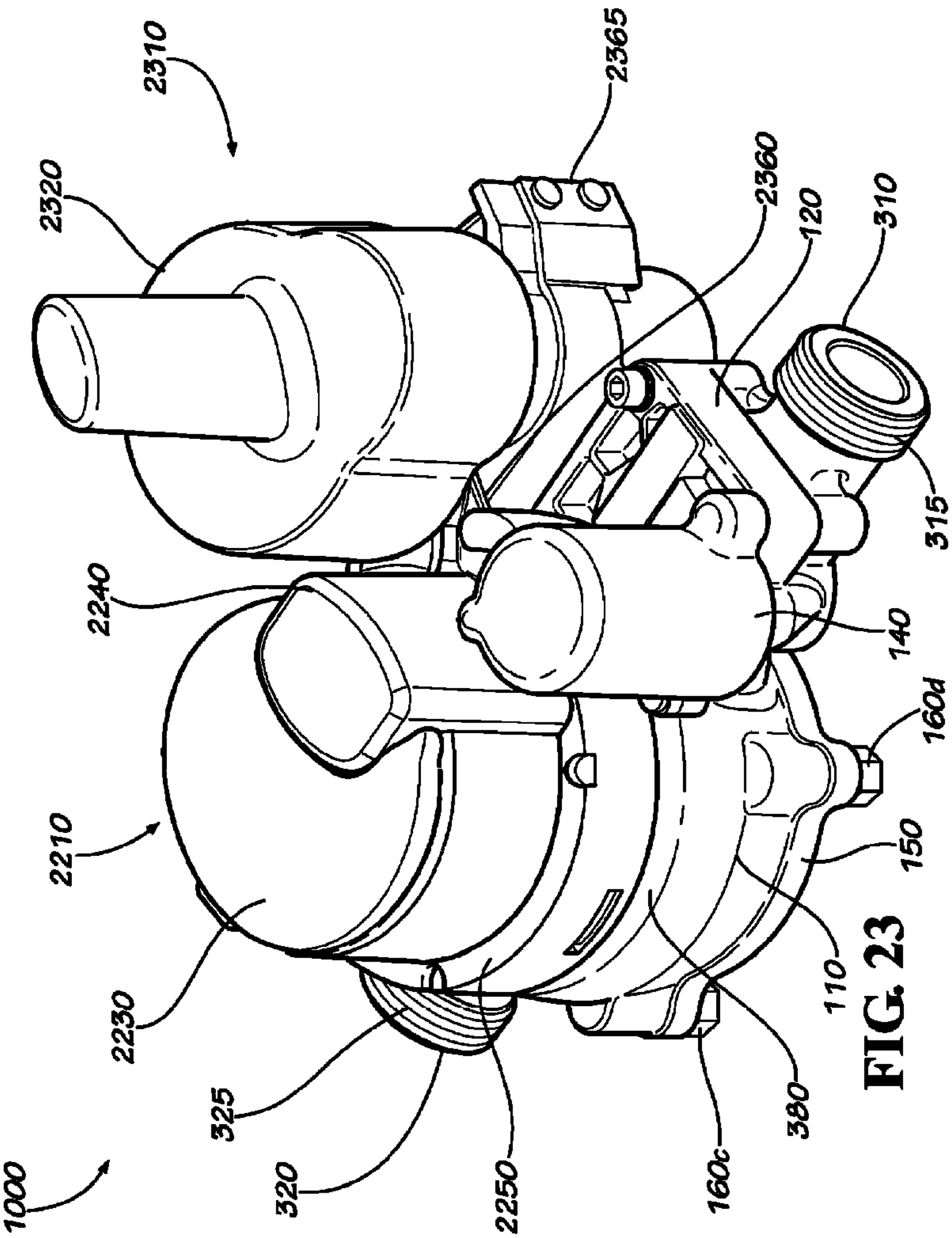
2310
2365
2320
2360
120
310
315
2240
140
160d
2210
150
110
2230
325
320
2250
160c
380
1000

FIG. 23

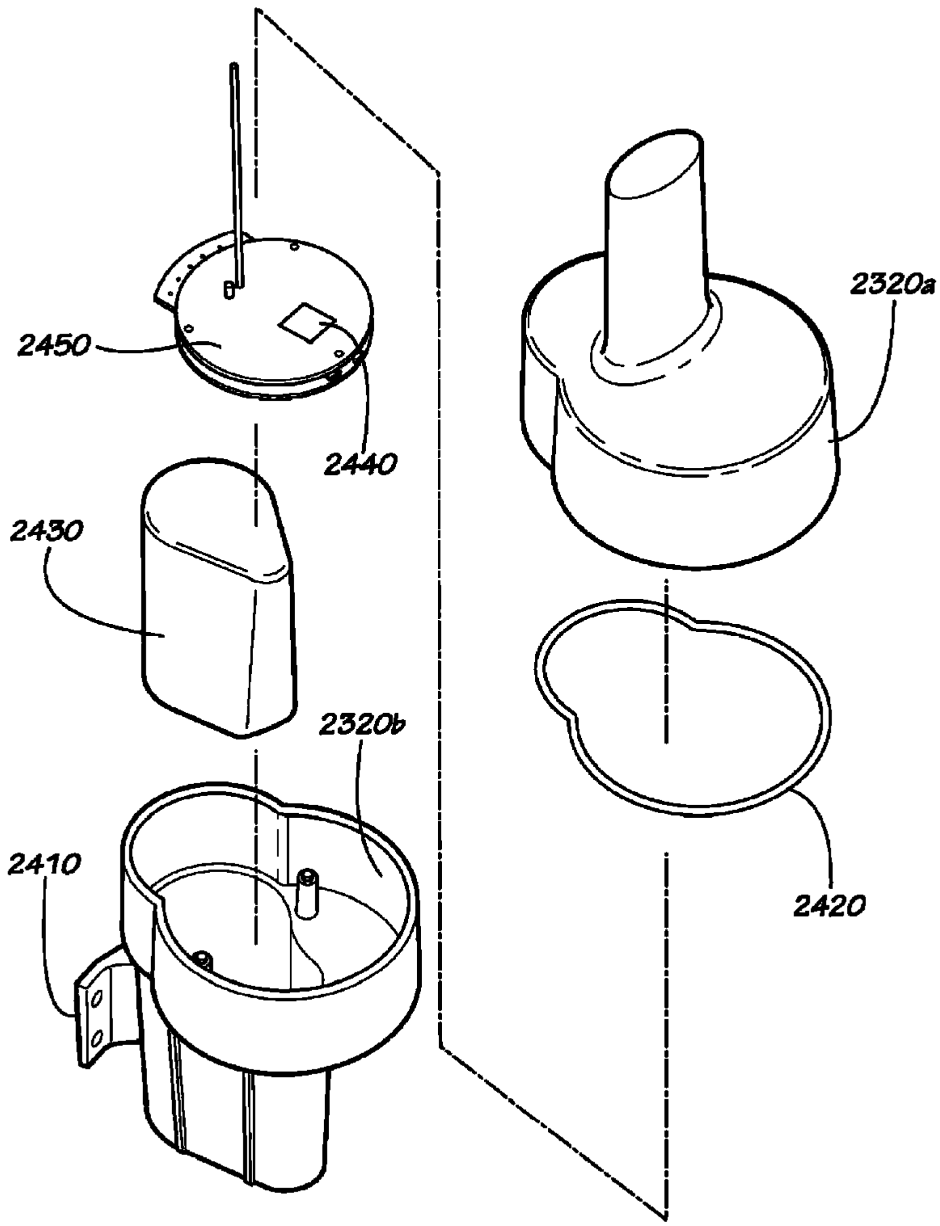

FIG. 24

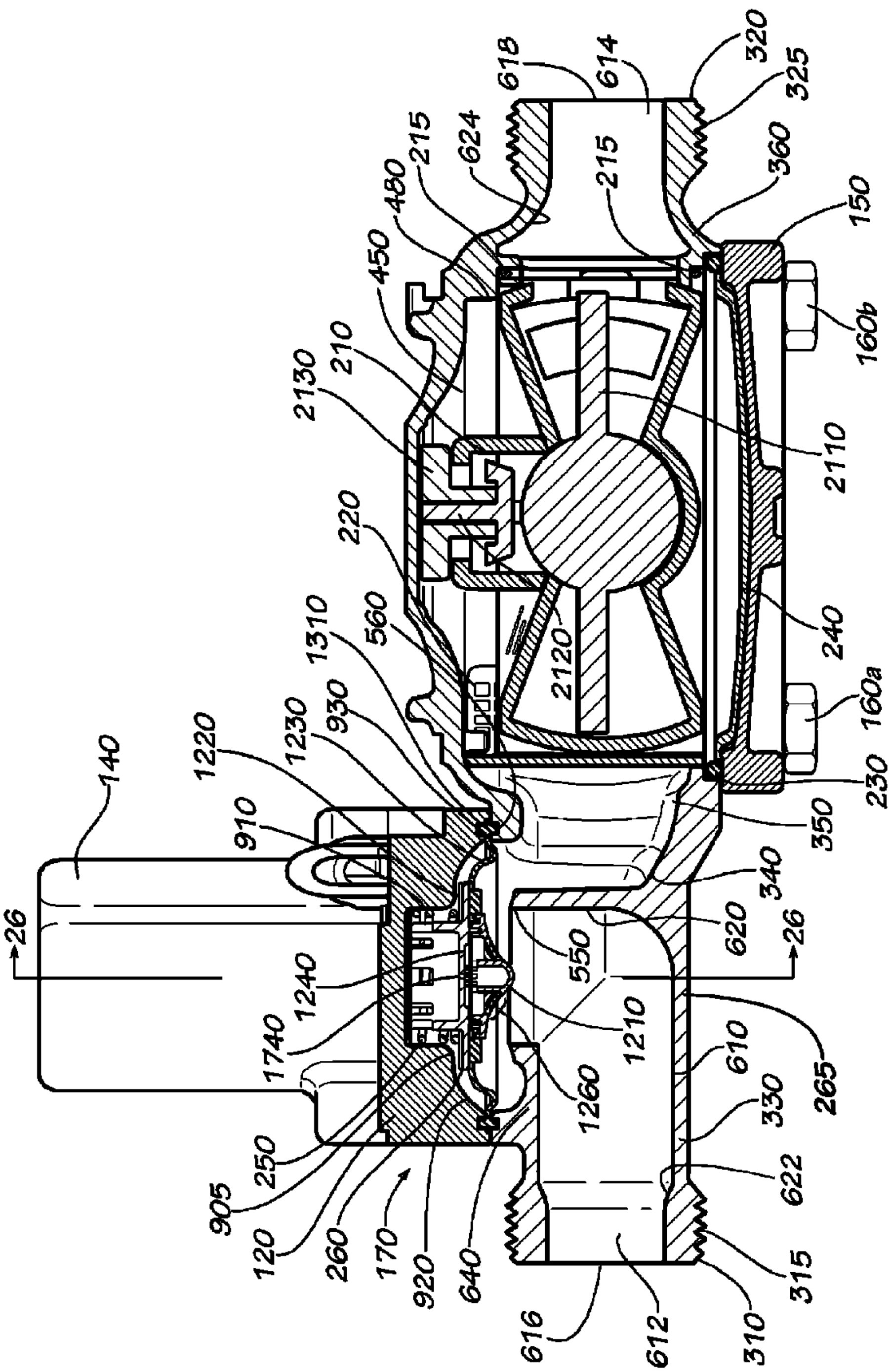
320
325
614
618
360
150
624
215
215
480
450
160b
210
2130
2110
220
240
560
1310
2120
160a
930
1230
1220
140
230
350
910
340
620
26
26
550
1240
1210
1740
265
610
1260
330
250
905
622
120
260
170
920
640
616
612
310
315

FIG. 25

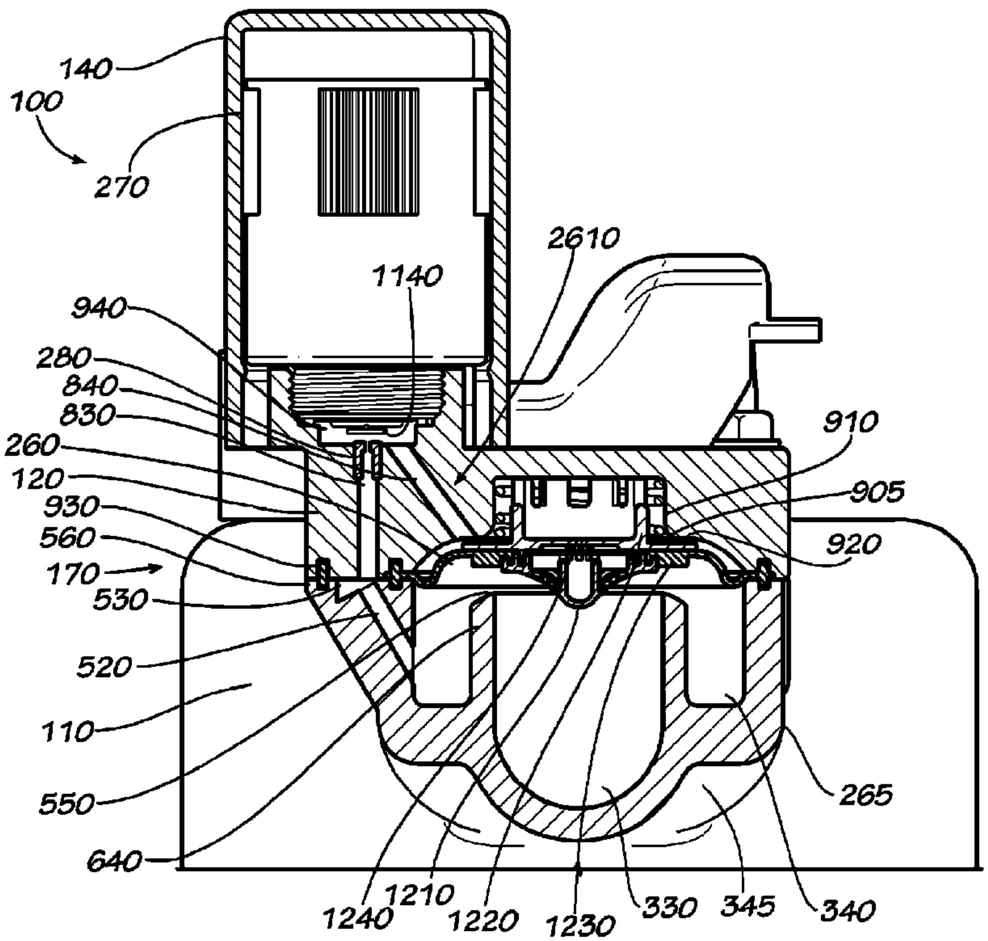
140
100
270
2610
1140
940
280
840
830
260
120
930
560
170
530
520
110
550
640
910
905
920
265
1240
1210
1220
1230
330
345
340

FIG. 26

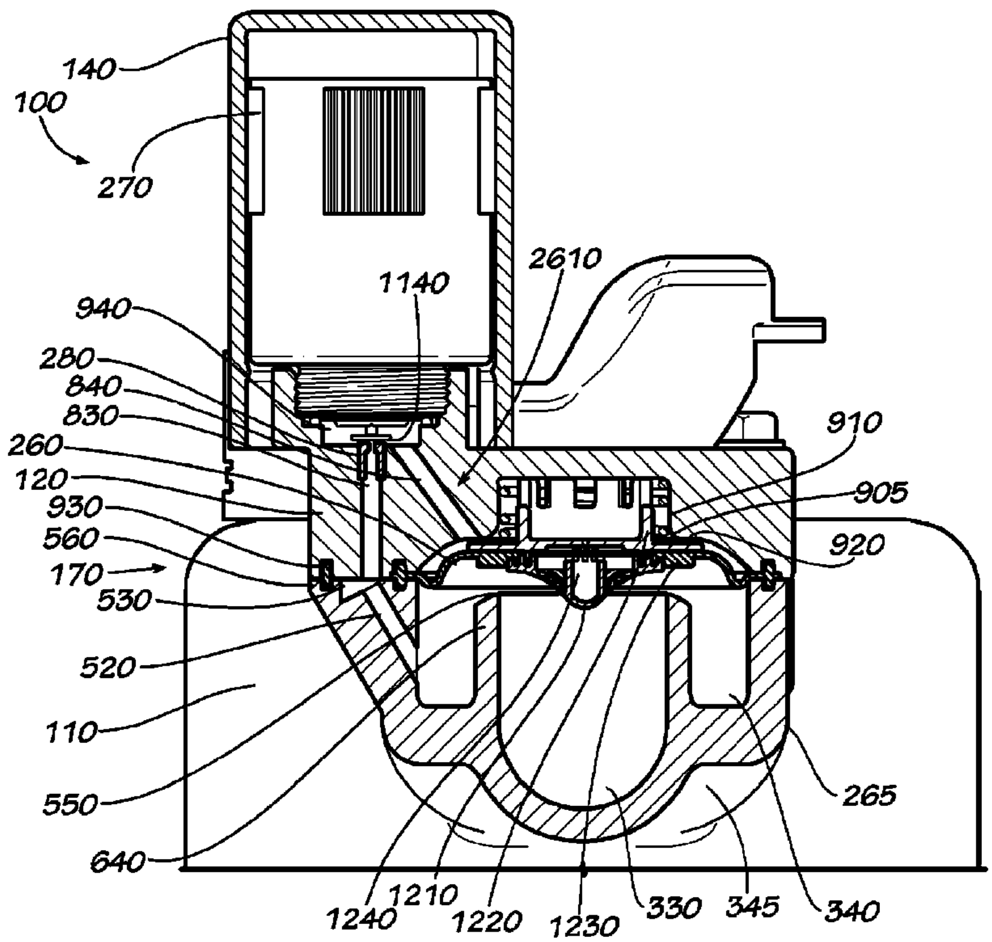
140
100
270
2610
1140
940
280
840
830
260
120
930
560
170
530
520
110
550
640
910
905
920
265
1240
1210
1220
1230
330
345
340

FIG. 27

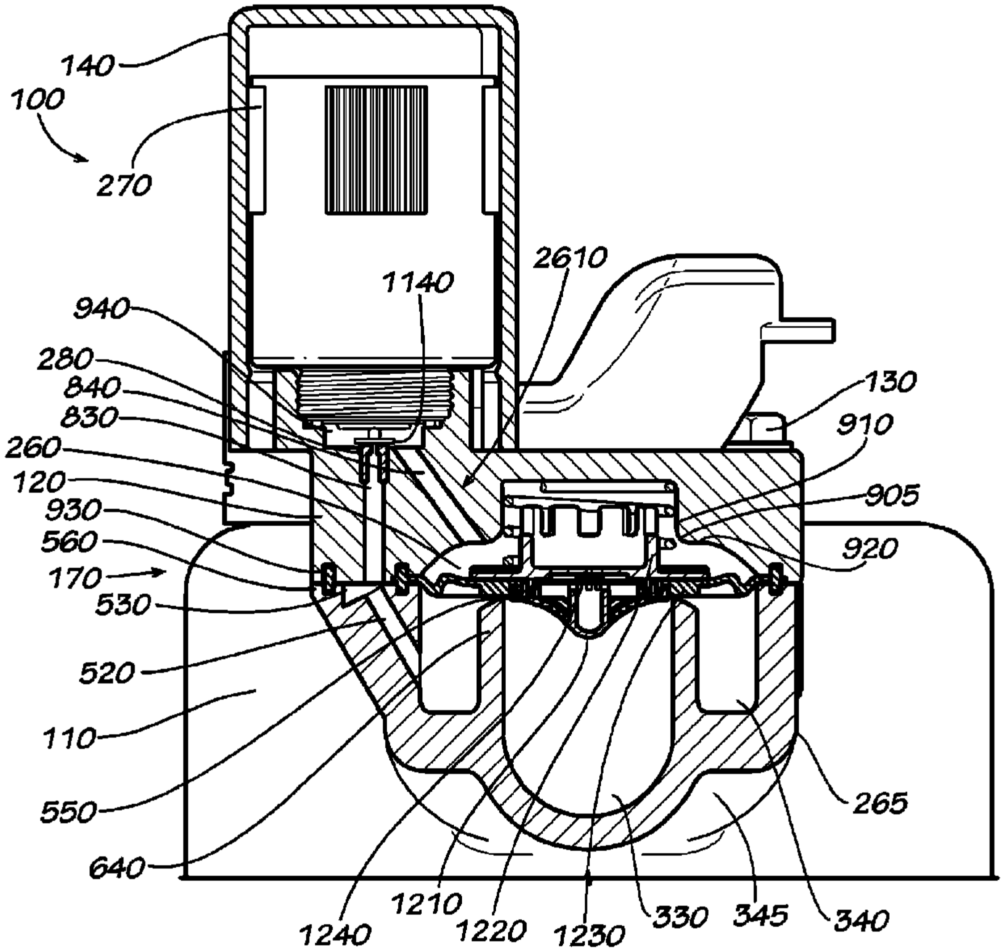
140
100
270
2610
1140
940
280
840
830
260
120
930
560
170
530
520
110
550
640
130
910
905
920
265
1240
1210
1220
1230
330
345
340

FIG. 28

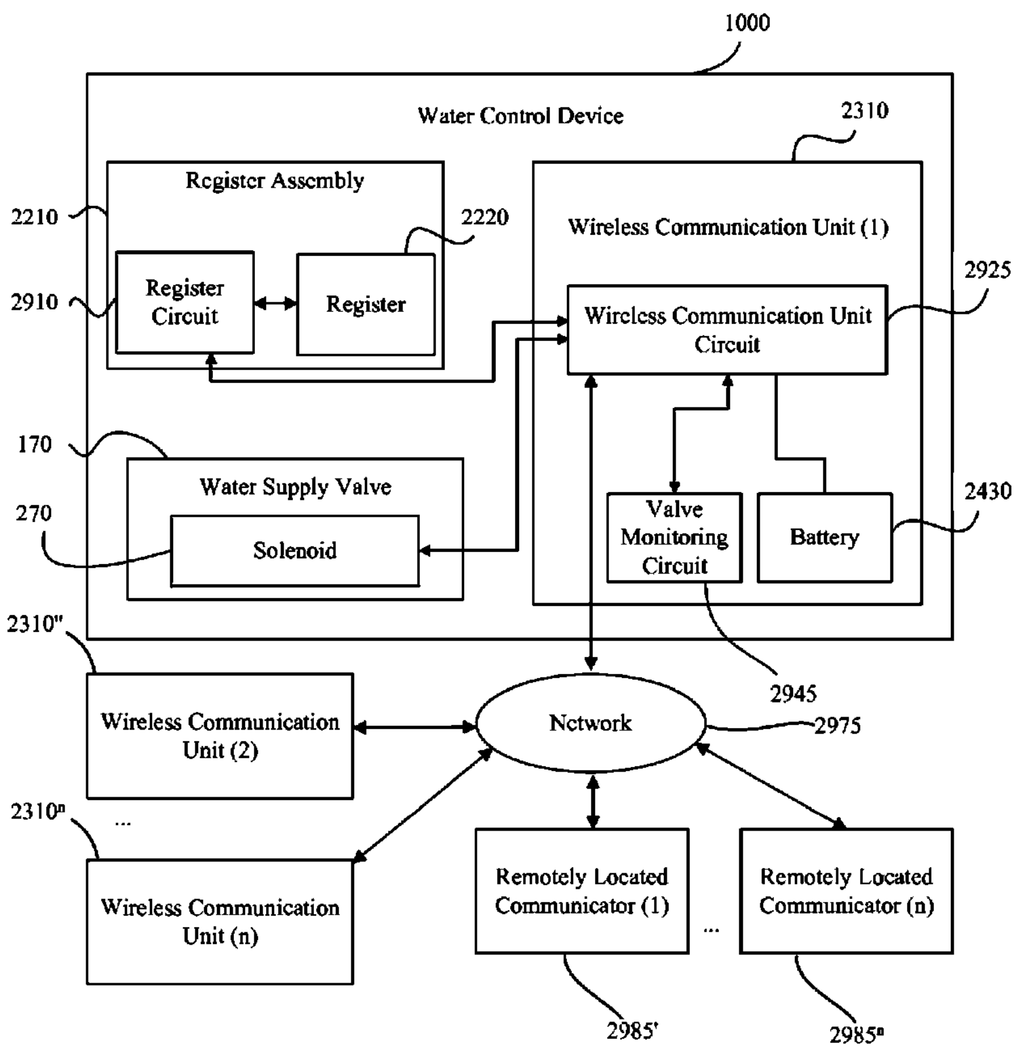
1000
Water Control Device
2310
Register Assembly
2210
2220
Wireless Communication Unit (1)
2910
Register Circuit
Register
2925
Wireless Communication Unit Circuit
170
Water Supply Valve
270
Solenoid
Valve Monitoring Circuit
Battery
2430
2310"
2945
Wireless Communication Unit (2)
Network
2975
2310ⁿ
...
Wireless Communication Unit (n)
Remotely Located Communicator (1)
...
Remotely Located Communicator (n)
2985'
2985ⁿ

FIG. 29

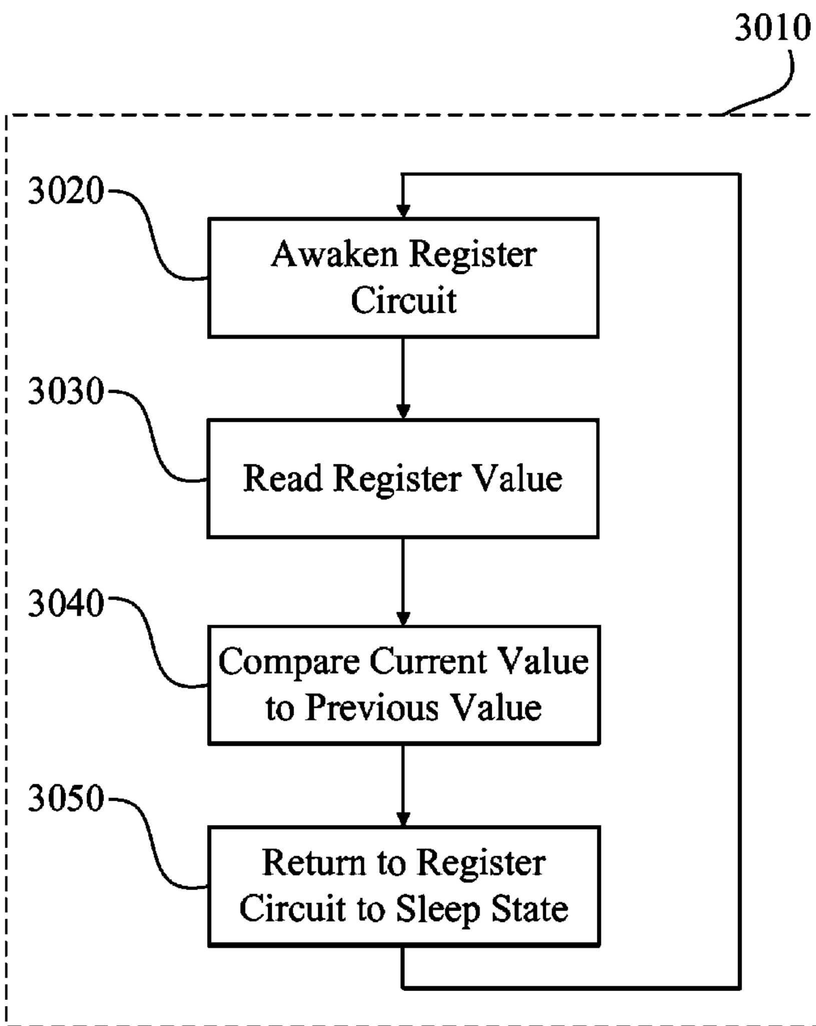
3010
3020
Awaken Register Circuit
3030
Read Register Value
3040
Compare Current Value to Previous Value
3050
Return to Register Circuit to Sleep State

FIG. 30

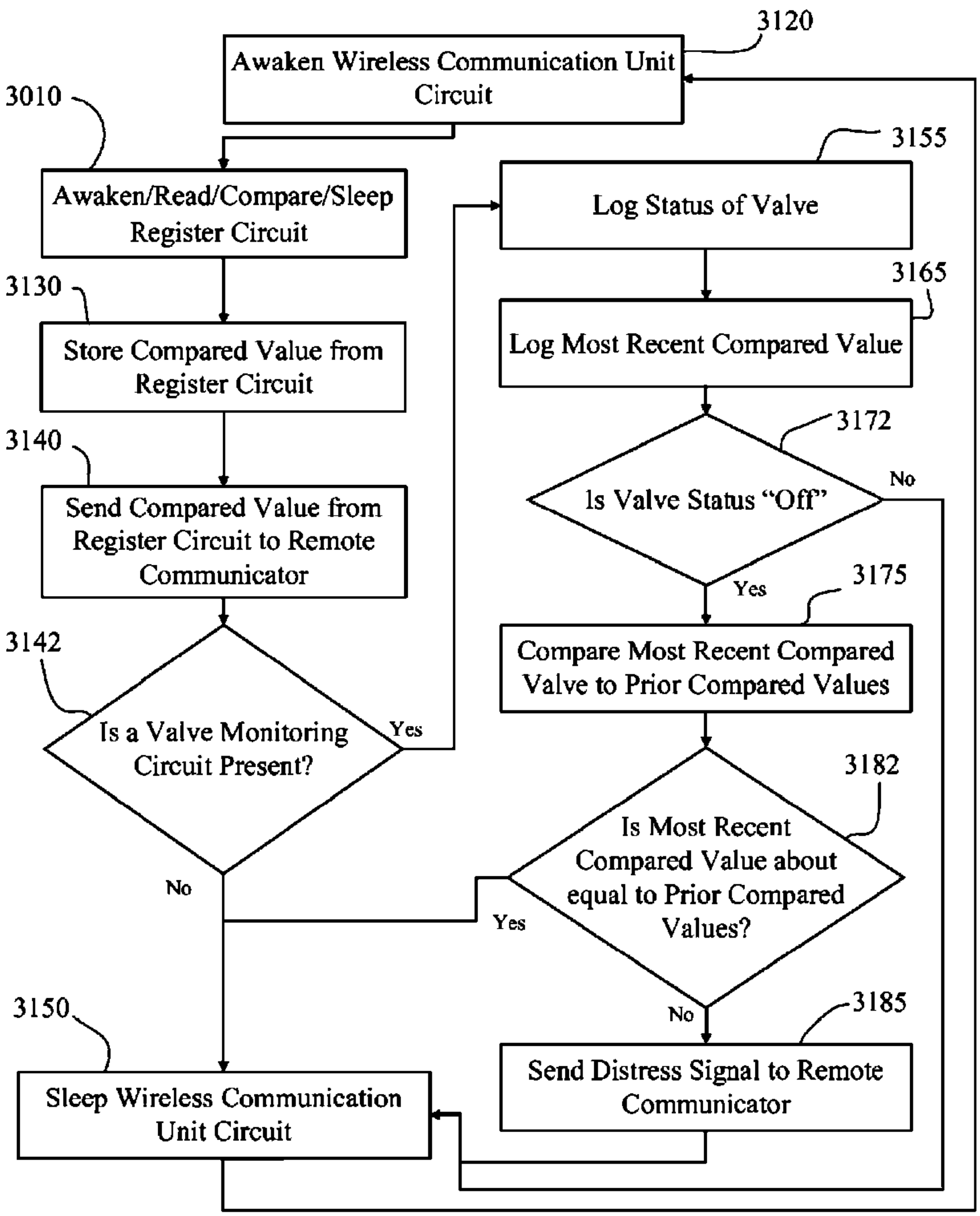
3120
Awaken Wireless Communication Unit Circuit
3010
Awaken/Read/Compare/Sleep Register Circuit
3130
Store Compared Value from Register Circuit
3140
Send Compared Value from Register Circuit to Remote Communicator
3142
Is a Valve Monitoring Circuit Present?
Yes
No
3155
Log Status of Valve
3165
Log Most Recent Compared Value
3172
Is Valve Status "Off"
No
Yes
3175
Compare Most Recent Compared Valve to Prior Compared Values
3182
Is Most Recent Compared Value about equal to Prior Compared Values?
Yes
No
3185
Send Distress Signal to Remote Communicator
3150
Sleep Wireless Communication Unit Circuit

FIG. 31

VALVE METER ASSEMBLY AND METHOD

TECHNICAL FIELD

The present disclosure relates to water control and metering, specifically water flow monitoring and control.

BACKGROUND

Water is typically supplied by a water provider which is usually a municipality. Water providers deliver water to businesses and individuals via piping systems. A piping system could be an upstream piping system, including a system to carry water from a water provider to a meter, or a downstream piping system, including a system to carry water from a meter to a user terminal. Because water providers typically sell water by unit volume, there exists a need to measure water flow to a user terminal to generate a water bill. As used herein, user terminal may include an individual residence, a place of business or any other point of termination of the water flow. Typically, a water meter will be placed in the water supply line between the water source and the user terminal to measure all water flowing to that user terminal. Meters are read and checked against prior readings to determine the total flow of water to the user terminal.

When a water user has not provided payment for water already used, it is typical in the industry for a water provider to discontinue supplying water to the user terminal associated with the water user. Typically, a water provider will install a manual water supply valve in the supply line in anticipation of the need to discontinue water supply. Although the valve may be operated rarely, a manual valve is standard equipment for water providers.

Typically, water meters are read manually by water meter readers who are employees or contractors of the water providers. Additionally, it is also typical that water supply valves are manually operated by employees or contractors of the water providers. These manual operations associated with providing water represent a significant cost of a typical water provider. With the advent of wireless technology, water providers have sought methods and systems for remote reading of water meters and/or remote control of water supply valves.

Mesh networks for remote reading of water meters exist currently. Systems for remotely controlling the water supply valve exist currently. However, these systems are often cumbersome to implement, requiring excavation and replacement of water supply lines to implement a remotely controlled water supply valve. Electronic remote control of valves and reading of meters has been implemented through wired connections. While wireless systems for controlling valves or for reading meters do exist, the cast ferrous materials used to make most water meter housings can interfere with wireless signals, so the wireless equipment often cannot be placed in close proximity to typical meter housings. Moreover, a remotely controlled valve typically involves a separate system and apparatus from a remotely readable water meter. Systems that integrate a shutoff valve and water meter together are often too large to be installed without excavation of the water supply lines and are typically difficult to service if parts fail. Some systems designed to fit into the standard water meter lay-length of a water meter provide inordinate head loss through the system and provide only remote control of the valve and no ability to read the meter remotely. Moreover, wireless water supply valves typically have relatively short operative lives because their operation requires large amounts of energy.

DESCRIPTION OF THE FIGURES

The features and components of the following figures are illustrated to emphasize the general principles of the present disclosure and are not necessarily drawn to scale. Corresponding features and components throughout the figures may be designated by matching reference characters for the sake of consistency and clarity.

FIG. **1** is a perspective view of a valve meter device in accordance with one embodiment of the disclosure.

FIG. **2** is an exploded view of the valve meter device of FIG. **1**.

FIG. **3** is a side view of the device housing of the valve meter device of FIG. **1**.

FIG. **4** is a bottom view of the device housing of FIG. **3**.

FIG. **5** is a top view of the device housing of FIG. **3**.

FIG. **6** is a sectional view of the device housing of FIG. **5** taken in a plane indicated by line **6** in FIG. **5**.

FIG. **7** is a sectional view of the valve portion of the device housing of FIG. **5** taken in a plane indicated by line **7** in FIG. **5**.

FIG. **8** is a top view of the valve cover of the valve meter device of FIG. **1**.

FIG. **9** is sectional view of the valve cover of FIG. **8** taken in a plane indicated by line **9** in FIG. **8**.

FIG. **10** is a bottom view of the valve cover of FIG. **8**.

FIG. **11** is a side view of the solenoid of the valve meter device of FIG. **1**.

FIG. **12** is an exploded view of the diaphragm assembly of the valve meter device of FIG. **1**.

FIG. **13** is a top view of the diaphragm of the diaphragm assembly of FIG. **12**.

FIG. **14** is a sectional view of the diaphragm of FIG. **13** taken in a plane indicated by line **14** in FIG. **13**.

FIG. **15** is a top view of the valve cone of the diaphragm assembly of FIG. **12**.

FIG. **16** is a sectional view of the valve cone of FIG. **15** taken in a plane indicated by line **16** in FIG. **15**.

FIG. **17** is a bottom view of the backing plate of the diaphragm assembly of FIG. **12**.

FIG. **18** is a top view of the backing plate of FIG. **17**.

FIG. **19** is a sectional view of the backing plate of FIG. **17** taken in a plane indicated by line **19** in FIG. **18**.

FIG. **20** is a sectional view of the diaphragm assembly of the valve meter device of FIG. **1** taken in a plane proceeding over the diameter of the assembly.

FIG. **21** is a sectional view of the water meter of the valve meter device of FIG. **1** taken in a plane proceeding through the center axis of the flow path of water through the valve meter device FIG. **1**.

FIG. **22** is a side view of a register assembly included in accord with one embodiment of the valve meter device of FIG. **1**.

FIG. **23** is a perspective view of a valve meter assembly including the valve meter device of FIG. **1**, the register assembly of FIG. **22**, and a wireless communication unit included in accord with one embodiment of the disclosure.

FIG. **24** is an exploded view of the wireless communication unit of the valve meter device of FIG. **23**.

FIG. **25** is a sectional view of the valve meter device of FIG. **1** taken in a plane proceeding through the center axis of the flow path of water through the valve meter device.

FIG. **26** is a sectional view of the valve meter device of FIG. **1** taken in a plane indicated by line **26** in FIG. **25** wherein the valve meter device is in the "open" state with the water supply valve and solenoid "open."

FIG. 27 is the sectional view FIG. 26 wherein the valve meter device is in a dynamic state with the solenoid in the "closed" position and the water supply valve in the "open" state.

FIG. 28 is the sectional view FIG. 26 wherein the valve meter device is in the "closed" state with the water supply valve and solenoid "closed."

FIG. 29 is a circuit diagram of the valve meter assembly of FIG. 23.

FIG. 30 is a flow diagram illustrating functioning of a register circuit of the valve meter assembly of FIG. 23.

FIG. 31 is a flow diagram illustrating functioning of a wireless communication unit circuit, including a valve monitoring circuit, of the valve meter assembly of FIG. 23.

DETAILED DESCRIPTION

Disclosed is a valve meter device, a valve meter assembly, and a method for remotely reading a water meter and controlling a water supply valve. The valve meter device includes a water supply valve and a water meter dimensioned together to fit within a standard water meter lay-length with reduced head loss. The valve meter device includes a water meter and at least part of a water supply valve together in one housing.

In one embodiment, the valve meter device is capable of communicating with a remotely located communicator. The remotely located communicator may receive signals from the valve meter device, send signals to the valve meter device, or both send signals to and receive signals from the valve meter device.

FIG. 1 is a perspective view of one embodiment of a valve meter device **100**. The valve meter device **100** includes a device housing **110**. The device housing **110** forms the main body through which water will flow. A valve cover **120** is attached to the device housing **110** using valve cover screws **130***a,b* (**130***c,d* not shown). A solenoid tamper cover **140** is attached to the top of the valve cover **120**. A bottom plate **150** is attached to the device housing **110** with bottom plate screws **160***a,b* (**160***c,d* not shown). In this disclosure, references to "top", "bottom", "down", "up", "downward", or "upward" refer to the valve meter device **100** as oriented in FIG. 1. Various features of the valve meter device **100** may be altered, reoriented, reconfigured, replaced, rotated, or moved in alternative embodiments. No one configuration is intended to be limiting on this disclosure.

The valve meter device **100** includes a water supply valve **170** and a water meter **210** (shown in FIG. 2). The water supply valve **170** is partially integrated with the device housing **110** and includes the valve cover **120** screwed onto the device housing **110** to enclose some components of the water supply valve **170** inside a cavity defined between the valve cover **120** and the device housing **110**. Although the current embodiment includes a partially integrated construction with a separately attached cover, alternative embodiments are included in this disclosure and may include a plastic welded assembly, separate valve and device housing subassemblies connected together via plastic welding, or separate valve and device housing subassemblies connected together mechanically, among others.

FIG. 2 is an exploded view of the valve meter device **100**. The device housing **110** includes a meter portion **264** and a valve portion **265**. The device housing **110** and bottom plate **150** are configured to enclose a water meter **210** and a strainer retainer **220** in the meter portion **264**. The bottom plate **150** is attached to the device housing **110** with bottom plate screws **160***a-d*. A meter gasket **230** is inserted between the bottom plate **150** and the device housing **110**. A bottom plastic liner **240** is inserted between the bottom plate **150** and the device housing **110**. The meter **210** in the current embodiment is a nutating disc displacement flow meter. Other meter types may be used with the valve meter device **100**. The meter **210** has a metering inlet **212** and a metering outlet **213** located proximate to each other. The metering outlet **213** is surrounded by a metering outlet rubber gasket **215**.

The valve cover **120** and the valve portion **265** of the device housing **110** enclose a spring **250** and a diaphragm assembly **260**. The solenoid tamper cover **140** encloses a solenoid **270** and a valve orifice cylinder **280** onto the valve cover **120**. The valve orifice cylinder **280** is a steel cylinder with a cylindrical bore extending its entire top to bottom length. The solenoid **270** is attached to the valve cover **120**. The valve orifice cylinder **280** sits in a media channel **520** (seen in FIG. 5) and interacts with the solenoid **270** to change water flow through the media channel **520** when the solenoid **270** is placed in an "open" or a "closed" position. The valve orifice cylinder **280** has a cylindrical shape in the current embodiment, but the valve orifice cylinder **280** may be various shapes. A solenoid tamper cover screw **290** provides the attachment of the solenoid tamper cover **140** to the valve cover **120**.

In alternative embodiments, the spring **250** may not be required for valve operation. Other parts of the water supply valve **170**, including the solenoid tamper cover **140**, may not be necessary in alternative embodiments of the valve meter device **100**. The valve cover **120** and the valve portion **265** of the device housing **110** are screwed together to enclose the optional spring **250** and the diaphragm assembly **260** using valve cover screws **130***a,b,c,d*.

As illustrated in FIG. 3, the device housing **110** has an inlet **310** and an outlet **320**. Water flows through the device housing **110** by flowing into the inlet **310** and the out of the outlet **320**. The inlet **310** includes an inlet end **616** (shown in FIG. 6), an inlet threaded portion **315**, an inlet neck **622** (shown in FIG. 6), and an inlet opening **612** (shown in FIG. 6). The outlet **320** includes an outlet end **618** (shown in FIG. 6), an outlet threaded portion **325**, an outlet neck **624** (shown in FIG. 6), and an outlet opening **614** (shown in FIG. 6). The inlet threaded portion **315** and the outlet threaded portion **325** allow for attachment to a piping system, including an upstream piping system or a downstream piping system or both. The inlet opening **612** and outlet opening **614** are connected by a flow channel **691** (shown in FIG. 6) that extends from the inlet end **616** to the outlet end **618** and passes through the inside of the device housing **110**. Water flows into the inlet **310** from a provider or water source and out of the outlet **320** to a home, office building, or other user terminal. Both the inlet **310** and the outlet **320** are attachable to the piping system via the inlet threaded portion **315** and outlet threaded portion **325**, respectively, with a coupling nut (not shown).

FIG. 3 illustrates the valve portion **265** and meter portion **264** of the device housing **110**. To reduce head loss, the water supply valve **170** (including the valve portion **265**) and the meter **210** (placed in the meter portion **264**) are oriented such that at least a portion of each of the water supply valve **170** and the meter **210** touch an imaginary line drawn between the inlet **310** and the outlet **320** thereby forming an "in line" configuration. The "in line" configuration is not achieved by staggering water supply valve **170** and the meter **210**, as such staggering may result in unacceptable head loss. In the current embodiment, the maximum acceptable head loss is 6 psi at 20 gallons per minute, although other embodiments may include other limits. To avoid staggering of the water supply valve **170** and the meter **210**, the "in line" configuration is achieved by using suitably sized components (such as valves

adequately sized for rated pressure in the system and piping diameter not larger than necessary for required flow), reducing wall thicknesses of the housing, shortening features including the inlet **310** and outlet **320**, and using water supply valve **170** with a coaxial valve inlet portion **330** and valve outlet portion **340**. However, the "in line" configuration does not indicate that components of the valve meter device **100**, including the meter **210** and water supply valve **170**, are located along the same horizontal plane. Should components or features, including the water supply valve **170** and the meter **210**, of the valve meter device **100** be staggered such that the components are not along the same horizontal plane, such a configuration typically is arranged to accommodate other requirements, such as an uneven piping system or multiple inlet or outlet configurations, and not to address the requirement of fitting the valve meter device **100** into a standard water meter lay-length.

Although the current embodiment has the valve portion **265** proximate the inlet **310** and the meter portion **264** proximate the outlet **320**, the placement of these or other portions of the device housing **110** or the valve meter device **100** may be rearranged. As illustrated in FIG. **3** (as well as FIG. **6**), the valve portion **265** includes a valve inlet portion **330** and a valve outlet portion **340** which overlap each other. Part of the valve inlet portion **330** is coaxial with part of the valve outlet portion **340** in the current embodiment. The valve outlet portion **340** has a slanted bottom portion **345** that is slanted from the inlet side of the water supply valve **170** to the outlet side of the water supply valve **170** to encourage water flow to the valve outlet portion **340**. The slant helps reduce head loss by promoting consistent flow. A meter inlet portion **350** is attached to the valve outlet portion **340**. The meter inlet portion **350** is also attached to the meter portion **264**. A meter outlet portion **360** exists between the meter portion **264** and the outlet **320**.

The inlet **310** and outlet **320** are portions of the device housing **110** in the current embodiment. In alternative embodiments, the inlet **310** and outlet **320** may be separate pieces connected to the device housing **110**. The device housing **110** is dimensioned so that it can fit within a standard water meter lay-length. The standard water meter lay-length of a standard water meter is designated in various industry standards documents, including the American Water Works Association (AWWA). The AWWA C700 standard requires 7.5 inches standard water meter lay-length for meters with ⅝-inch piping diameter. Other AWWA standards, such as C708 and C710, also specify the same laying lengths for meters of like sizes.

A top portion **380** of the meter portion **264** includes a register connection interface **385**. The register connection interface **385** includes several teeth **390***a,b,c,d* (**390***e,f* shown in FIG. **5**) designed to attach a separate register assembly **2210** (shown in FIG. **22**) to the top portion **380**. A bottom portion **395** of the meter portion **264** is configured to accept the bottom plate **150** attaching to the device housing **110**. The bottom portion **395** and the bottom plate **150** may be connected via a threaded interaction, a screw and bore attachment, or a welded attachment, among others. For maximum wireless communication capabilities, the device housing **110** may be composed of brass, bronze, plastic, aluminum, or other non-ferrous material. The device housing **110** may also be made of ferrous materials based on the specific application.

FIG. **4** is a bottom view of the device housing **110**, including the inlet **310**, the valve inlet portion **330**, the valve portion **265**, the valve outlet portion **340**, the meter inlet portion **350**, the meter portion **264**, the meter outlet portion **360**, and the outlet **320**.

The valve inlet portion **330** extends from the inlet neck **622** (not shown) to the valve outlet portion **340**. The valve inlet portion **330** terminates inside the valve outlet portion **340** on a concentric profile, as illustrated in later figures.

The meter portion **264** of the device housing **110** is sized to define a meter cavity **450**. Although the current embodiment of the meter portion **264** is cylindrical, the meter portion **264** need not be a specific shape, but need only accommodate the meter **210**. Wall **460** of the meter portion **264** is sized to accommodate the water pressure of the piping system. The meter portion **264** also includes four threaded bottom plate attachment bores **470***a,b,c,d* for attachment of the bottom plate **150** with the bottom plate screws **160***a,b,c,d* (as seen in FIG. **2**).

Inside the meter cavity **450** of the device housing **110**, a meter outlet standoff **480** is shaped to accommodate the metering outlet rubber gasket **215** of the meter **210** to seal the connection (as seen in FIG. **2**). Meter cavity standoffs **490***a,b* are also provided in the meter cavity to prevent the meter from jostling under the flow of water and to retain the strainer retainer **220** in position between the meter inlet portion **350** and the meter **210**.

Turning to FIG. **5**, the valve portion **265** includes four threaded valve cover bores **510***a,b,c,d* for attachment of the valve cover **120** to the valve portion **265** of the device housing **110**. In the current embodiment, the valve cover **120** is attached using four valve cover screws **130***a,b,c,d* (shown in FIGS. **1** and **2**) that attach through the valve cover **120** to each valve cover bore **510***a,b,c,d*. As noted above, the attachment could also be achieved using welding, which would obviate any need for valve cover bores **510***a,b,c,d* or valve cover screws **130***a,b,c,d*. The valve portion **265** of the device housing **110** also includes a media channel **520** which is a bore that extends from the valve outlet portion **340** to a media channel relief **530** in the device housing **110**. A diaphragm ring recess **560** lines the top of the valve portion **265** and the media channel relief **530**. The beveled edge **550** seals the water supply valve **170** in operation.

As illustrated in the embodiment in FIG. **6**, the valve inlet portion **330** communicates with the inlet neck **622** of the device housing **110**. In one embodiment, the valve inlet portion **330** has an inner diameter sized larger than the inner diameter of the inlet neck **622** to reduce head loss through the water supply valve **170**. The valve outlet portion **340** communicates with the meter inlet portion **350** of the device housing **110**. The valve portion **265** includes the valve inlet portion **330** and the valve outlet portion **340** and all related transitional portions. In the current embodiment, the valve portion **265** is integrated with the device housing **110**. However, alternative embodiments are contemplated herein, including separate housing units for the valve portion **265** and the meter portion **264** which are mechanically joined.

As illustrated in FIG. **6**, a linear distance **665** exists between inlet end **616** and outlet end **618** of the device housing **110**. In the current embodiment, linear distance **665** is 7.5 inches to comply with American Water Works Association standard AWWA C700. The flow channel **691** in the device housing **110** extends from the inlet end **616** to the outlet end **618**.

The valve inlet portion **330** includes a horizontal portion **610** and a vertical portion **620**. In the current embodiment, the horizontal portion **610** and vertical portion **620** form a right angle, although other angular configurations are acceptable and are contemplated by this disclosure. The horizontal por-

tion **610** extends from the inlet **310** to a location proximate to the center of the water supply valve **170**. At this location, the horizontal portion **610** merges into the vertical portion **620**. The vertical portion **620** extends vertically inside the valve outlet portion **340**. The valve outlet portion **340** of the device housing **110** includes the slanted bottom portion **345**. The slanted bottom portion **345** of the valve outlet portion **340** directs water to the meter inlet portion **350** of the device housing **110**. It should be noted that the configuration of inlets and outlets may be reversed in other embodiments. For example, the valve inlet portion **330** may be positioned on the outside of the valve outlet portion **340** in an alternative embodiment, whereas the valve outlet portion **340** is positioned on the outside of the valve inlet portion **330** in the current embodiment. A top edge portion **640** of the valve inlet portion **330** includes the beveled edge **550**. The valve portion **265** of the device housing **110** also includes the diaphragm ring recess **560**. A valve transition portion **670** allows the merger of the valve inlet portion **330** to the valve outlet portion **340**.

As illustrated in FIG. **6**, the device housing **110** has an outer surface **680** and an inner surface **690**. At the water supply valve **170**, the valve inlet portion **330** transitions to the valve outlet portion **340** having the valve cover **120** (see FIG. **25**) placed over the valve transition portion **670**. The meter cavity **450** and the bottom plate **150** enclose the meter **210** (see FIG. **25**). The inner surface **690** defines the flow channel **691** in the device housing **110**. The water supply valve **170** is also in sealable communication with the flow channel **691**.

In one embodiment of the valve meter device **100**, the meter inlet portion **350** is substantially rectangular to reduce head loss as water flows out of the valve outlet portion **340**, through the meter inlet portion **350**, and into the meter cavity **450**. Reduced head loss is achieved because the rectangular cross-section provides a larger cross-section through which water may flow than a rounded cross-section.

The sectional view of device housing **110** shown in FIG. **7** illustrates the placement of the media channel **520** that exists between the media channel relief **530** and the valve outlet portion **340**.

FIG. **8** is a top view of the valve cover **120**. Four screw bores **810***a,b,c,d* are located at the corners of the valve cover **120**. A solenoid attachment portion **820** is a cylindrical boss including a threaded solenoid attachment sink **825** on the inside of the boss. A valve cover media channel **830** is aligned with the center of the solenoid attachment sink **825**. The valve cover media channel **830** passes through the valve cover **120** and aligns with the media channel **520** when the valve meter device **100** is assembled. A valve cavity media channel **840** is also shown in the solenoid attachment portion **820**. The valve cover **120** in the current view of the current embodiment also includes casting recesses **850** and a serial plate **860**. A threaded solenoid cover screw bore **870** is located in a protrusion **875**. Although the valve cover **120** is rectangular in shape, one side of the valve cover **120** includes a curve **880**. The curve **880** is included to provide clearance for the register assembly **2210** to be placed on the valve meter device **100**. A countercurve protrusion **890** is proximate the bottom of the curve **880** to accommodate the diaphragm ring recess **560**.

As illustrated in the section view of the valve cover **120** in FIG. **9**, the valve cover **120** includes a valve cavity **905**. The valve cavity **905** and the valve portion **265** enclose components of the diaphragm assembly **260**. The valve cavity **905** and the valve portion **265** may also enclose the spring **250**. The valve cavity **905** also includes a valve recess **910** and a valve bonnet **920**, which together are shaped to accept the diaphragm assembly **260** and the spring **250**. The valve cover **120** also includes a diaphragm ring recess **930** shaped to align with the diaphragm ring recess **560**.

The solenoid attachment portion **820** is dimensioned to define a solenoid chamber **940** between the solenoid **270** and the valve cover **120** when the solenoid **270** is attached to the valve cover **120**. The valve cavity media channel **840** connects the valve cavity **905** with the solenoid chamber **940**. Although the valve cavity media channel **840** is shown to connect with the valve bonnet **920** in the current embodiment, the valve cavity media channel **840** may connect to any portion of the valve cavity **905**, including the valve recess **910**. Because the valve cover media channel **830** is aligned with the center of the solenoid attachment portion **820**, the valve cover media channel **830** connects to the solenoid chamber **940**. A valve orifice recess **950** is also seen in the valve cover media channel **830** to accommodate the valve orifice cylinder **280**. When the valve meter device **100** is assembled, the valve orifice cylinder **280** is placed into the valve orifice recess **950**. FIG. **10** is a bottom view of the valve cover **120**.

FIG. **11** shows the solenoid **270** of the valve meter device **100**. The solenoid **270** includes a solenoid body **1110**, a threaded attachment portion **1120**, and a plunger **1130**. The plunger **1130** includes a shaft portion **1135** and an interface portion **1140**. Although the solenoid in the current embodiment is designed to be attached via threaded interaction, other attachment means are contemplated, including glue, welding, and screw bore attachments among others. The solenoid tamper cover **140** covers the solenoid **270** when the valve meter device **100** is assembled. When the valve meter device **100** is assembled, the interface portion **1140** of the plunger **1130** may contact and seal the valve orifice cylinder **280**, as will be described later.

FIG. **12** is an exploded view of the diaphragm assembly **260**. The diaphragm assembly **260** includes a valve cone **1210**, a backing plate **1220**, a diaphragm **1230**, and a strainer **1240**. The strainer **1240** is a disc-shaped piece of straining material that traps impurities as water flows through the component. The strainer may be removed in alternative embodiments.

The valve cone **1210** is a conical-shaped plastic piece placed on the bottom side of the diaphragm **1230**. The valve cone **1210** is plastic because it is plastic welded in the assembly of the current embodiment. However, other joining interfaces which would invoke other possible material choices for the valve cone **1210** are contemplated by this disclosure. The valve cone **1210** is cone-shaped on an outer, downward-facing surface **1250**. The downward facing surface **1250** in the current embodiment is curved. However, the downward facing surface **1250** may be straight in alternative embodiments. The downward facing surface **1250** includes multiple water leak passthroughs **1260**.

FIG. **13** is a top view of the diaphragm **1230**. The diaphragm **1230** may be made of a flexible material. In the current embodiment the diaphragm **1230** is made of rubber. The flexibility of the diaphragm **1230** allows travel of the central portions (**1410,1420,1430,1440,1450**, described later) without movement of the edge portions (**1310,1320**, described later) as achieved by multiple wrinkled or corrugated portions (**1410,1420,1430**, described later) that may be stretched to achieve a desired throw. The diaphragm **1230** includes a gasketing diaphragm ring **1310**. A media channel seal ring **1320** is a looping portion of the diaphragm **1230** extending radially outward. The media channel seal ring **1320** is configured to seal the interface between the valve cover media channel **830** and the media channel **520**.

FIG. **14** is a sectional view of the diaphragm **1230**. The gasketing diaphragm ring **1310** is on the outer edge of the

diaphragm **1230**. Radially inward adjacent to the gasketing diaphragm ring **1310** is an attached outer flat portion **1410**. Radially inward adjacent to the outer flat portion **1410** is a forward throw corrugation **1420**. As shown, the forward throw corrugation **1420** is a rounded, semi-circular portion. Radially inward adjacent to the forward throw corrugation **1420** is a rearward throw corrugation **1430**. The rearward throw corrugation **1430** is a rounded, quarter-circular portion. Radially inset to the rearward throw corrugation **1430** is an inner flat portion **1440**. The inner flat portion **1440** defines a valve cone bore **1450**. The inner flat portion **1440** defines a valve cone groove **1460**. The valve cone groove **1460** interfaces with the valve cone **1210**. Further inset radially from the valve cone groove **1460** is a valve cone retainer **1470**. The valve cone retainer **1470** interfaces with the inside of the valve cone **1210**. As stated above, the media channel seal ring **1320** is not concentric because it extends radially outward. Although all components of the diaphragm are connected and integrated in the current embodiment, alternative embodiments may include separate pieces that may or may not be joined together. For example, the gasketing diaphragm ring **1310** may be a separate component in alternative embodiments.

FIG. **15** illustrates a top view of the valve cone **1210**. The valve cone **1210** has three main circular channel portion cutouts. A diaphragm retention channel **1520** is bounded by a shoulder **1530** that interfaces with the valve cone groove **1460**. Inset radially from the diaphragm retention channel **1520**, a weld channel **1540** provides a welding interface with the backing plate **1220**. Inset radially from the weld channel **1540**, a water leak channel **1550** includes features (described below) that communicate water from the valve inlet portion **330** to the valve cavity **905**. On the inner surface **1555** of the water leak channel **1550**, eighteen water subchannels **1560** are spaced twenty degrees apart circumferentially about the center axis of the valve cone **1210**. The number of subchannels and the configuration of pathways may change in alternative embodiments. In the center of the valve cone **1210** is a cylindrical standoff **1570**. The cylindrical standoff **1570** has multiple fins **1580** located at its top.

FIG. **16** shows a sectional view of the valve cone **1210**. The surface profile of the inner surface **1555** is complementary to the surface profile of the downward facing surface **1250**, providing a consistent wall thickness of the valve cone **1210** in that region. The depth of the water subchannels **1560** varies across each channel. A "stair step" depth pattern defines four water leak passthroughs **1260** per water subchannel **1560**. In total, seventy-two water leak passthroughs **1260** are assembled in groups of four spaced twenty degrees apart around the downward facing surface **1250**. The specific configuration of water leak passthroughs **1260** may be varied in alternative embodiments.

FIG. **17** shows a bottom view of the backing plate **1220**. The backing plate **1220** includes a downward facing surface **1710** and an upward facing surface **1810** (shown in FIG. **18**). The downward facing surface **1710** has a cylindrical weld portion **1720** where the backing plate **1220** will weld to the valve cone **1210**. Ten flow path portions **1730** are wedge-shaped cutouts in the downward facing surface. The specific number or shape of flow path portions may vary in alternative embodiments. The wedge-shaped cutouts **1730** prevent the strainer **1240** from becoming pushed flush against the backing plate **1220**. This allows water to flow through the diaphragm assembly **260**. A water leak hole **1740** is in the center of the backing plate **1220** to allow the flow of water through the backing plate **1220**.

FIG. **18** is a top view of the backing plate **1220**. The upward-facing surface **1810** includes a cylindrical spring portion **1820** sized to accommodate the optional spring **250** placed around it. The top of the cylindrical spring portion **1820** includes a fence **1830**. The fence **1830** operates to preserve water flow above the cylindrical spring portion **1820** and below the valve cover **120**. This space allows water to flow through the cylindrical spring portion **1820** into the valve bonnet **920**. The upward-facing surface **1810** includes several wedge-shaped standoffs **1840**. The wedge-shaped standoffs **1840** prevent the backing plate **1220** from becoming affixed by vacuum to the valve cover **120** in the valve recess **910**.

FIG. **19** is a sectional view of the backing plate **1220**. The cylindrical weld portion **1720** includes a weld edge **1910** that is sharpened to provide a welding interface between the backing plate **1220** and the valve cone **1210**.

FIG. **20** displays a sectional view of the diaphragm assembly **260**. The diaphragm assembly **260** includes the valve cone **1210** having its downward facing surface **1250** facing down and its upward facing surface **1510** facing up. The diaphragm **1230** is placed onto the valve cone **1210** with the diaphragm retention channel **1520** interfacing with the valve cone retainer **1470**. The shoulder **1530** is interfacing with the valve cone groove **1460**. The strainer **1240** is circular with perforations to allow water to flow through while trapping impurities. The strainer **1240** is centered on the valve cone **1210**. The backing plate **1220** is placed over the strainer **1240** and onto the valve cone **1210** and diaphragm **1230**. The cylindrical weld portion **1720** extends into the weld channel **1540** where it is welded with the valve cone **1210**. When the backing plate **1220** is welded to the valve cone **1210**, the diaphragm assembly **260** is complete with the strainer **1240** trapped inside the valve cone **1210** and the backing plate **1220** weld and the diaphragm **1230** trapped between the valve cone **1210** and the backing plate **1220**. Welding provides a water-tight seal between the valve cone **1210** and the backing plate **1220**.

FIG. **21** displays the meter **210**. The meter **210** is a standard nutating disc displacement flow meter. Other meters may also be used in lieu of the nutating disc displacement flow meter. Internal to the meter is a nutating disc **2110** that interfaces with an output register interaction shaft **2120**. The nutating disc **2110** includes a disc pin **2115** which engages the output register interaction shaft **2120**. In operation, the nutating disc **2110** and disc pin **2115** wobble about a fixed point in the meter to drive the output register interaction shaft **2120**. The output register interaction shaft **2120** is attached to a meter magnet **2130**. The meter magnet **2130** has a four-pole arrangement that coordinates with a register **2220** (shown in FIG. **22**) such that when the meter magnet **2130** turns the register **2220** logs the motion and provides a readout of water usage. It should be noted that any descriptions related to the functioning of the meter **210** and its interaction with any register **2220** are related to one embodiment of the invention, and other types of meters and registers may be used with the current and alternative embodiments of the disclosed device.

As seen in FIG. **22**, the register assembly **2210** includes the register **2220**, a register cover **2230**, a register bracket **2240**, and a housing attachment ring **2250**. The register **2220** is a magnetic interface register that interfaces with the meter **210** via a magnetic pole arrangement. The register **2220** has internal components and is externally made of glass or clear plastic having an external shape that is cylindrical. The housing attachment ring **2250** is a ring sized to encircle the register **2220**. The housing attachment ring **2250** has clamping teeth (not shown) that interface with the teeth ***390a,b,c,d,e,f*** of the device housing **110** to clamp the register assembly **2210** onto

the device housing **110**. The housing attachment ring **2250** is placed onto the register **2220** by inserting it over the top of the register **2220** and sliding it to the bottom of the register **2220**. Other means of attaching the register **2220** and register assembly **2210** to the device housing **110** are intended to be included within this and alternative embodiments.

In a valve meter assembly **1000**, the register assembly **2210** is connected to the top **380** of the device housing **110**, as shown in FIG. **23**. In an embodiment of the valve meter assembly **1000**, a communication device is included with the valve meter assembly **1000**. The communication device in some embodiments may be a wireless communication unit **2310**. In the current embodiment, the wireless communication unit **2310** is part of a mesh network where the mesh network includes the remotely located communicator. The remotely located communicator may be operated by a municipality, a technician, a service provider, or another entity. The remotely located communicator may be any communication device or system including a computer, a server, a gateway, another valve meter assembly, a handheld device, a mesh network, or any other device or system capable of communicating with the wireless communication unit **2310**. A bracket **2365** is provided for attachment of the wireless communication unit **2310**. In the valve meter assembly **1000**, the bracket **2365** is integrated with register bracket **2240** as an arm of the register bracket **2240**, although the bracket **2365** may be connected to, integrated with, or attached to other features of the valve meter assembly **1000**.

The wireless communication unit **2310** is shown in exploded view in FIG. **24**. The wireless communication unit **2310** has a two-part plastic cover **2320** having a top **2320*a*** and a bottom **2320*b***. The plastic cover **2320*a,b*** includes a bracket attachment portion **2410** for attachment to the bracket **2365** (shown in FIG. **23**) that may be included with the valve meter assembly **1000** to attach the wireless communication unit **2310**. Enclosed within the plastic cover **2320*a,b*** is a sealing gasket **2420**, a battery **2430**, a transceiver **2440**, and a printed circuit board (PCB) **2450**. Where a "printed circuit board" or PCB is included in the current description, any circuitry which functions as the PCB is intended to be included in alternative embodiments as a variant of a printed circuit board.

In an embodiment of the valve meter assembly **1000**, the wireless communication unit **2310** may receive signals from the remotely located communicator, or send signals to the remotely located communicator, or both. The wireless communication unit **2310** may include a wireless communication unit circuit **2925** (shown in FIG. **29**) as part of the PCB **2450**. The wireless communication unit circuit **2925** receives signals from the remotely located communicator. The signals may include valve control signals. The valve control signals may direct action of the solenoid **270** to open or to close and, thereby, to change the state of the water supply valve **170**. The wireless communication unit circuit **2925** controls the solenoid **270** in the current embodiment; however, alternative embodiments may include other control circuits for the solenoid **270**.

In one embodiment, the register assembly **2210** may include a PCB (not shown). With reference to the circuit diagram of FIG. **29** and the block diagrams of FIGS. **30** and **31**, the valve meter assembly **1000** includes the register assembly **2210** and the wireless communication unit **2310** in addition to the water supply valve **170**, which itself includes the solenoid **270**. The register assembly PCB may include a register circuit **2910** that reads the register **2220** electronically. The wireless communication unit **2310** includes the wireless communication unit circuit **2925** and is electrically connected to the register circuit **2910**. The wireless communication unit **2310** is also electrically connected to the solenoid **270**. As shown in FIG. **23**, wires **2360** provide the electrical connections. The wires **2360** may be enclosed with tamper-proof jacketing. The battery **2430** of the wireless communication unit **2310** may be included in the electrical circuitry. In one embodiment, the battery is a lithium thionyl battery. The wireless communication unit circuit **2925** performs functions which may include interaction with the register circuit **2910**, interaction with the water supply valve **170**, or communication with one or more remotely located communicators (shown as **2985**) via a network **2975**. In some embodiments, the wireless communication unit circuit **2925** may replace the register circuit **2910** through electrical connection of the register **2220** with the wireless communication unit **2310**. FIG. **29** also displays how the wireless communication unit **2310** is but one unit (wireless communication unit (1)) in a mesh network of wireless communication units (**2-*n***) (shown as **2310"** and **2310‴**), which may communicate with one or more remotely located communicators (**1-*n***) (shown as **2985'** and **2985″**).

FIG. **25** is a cross-sectional view of the assembled valve meter device **100** with the water supply valve **170** in an "open" state. The valve cover **120**, along with the valve portion **265** of the device housing **110**, encloses the diaphragm assembly **260** and spring **250**. The gasketing diaphragm ring **1310** is enclosed within the diaphragm ring recess **560** and the diaphragm ring recess **930**. The strainer retainer **220** is a porous fence that allows water to flow through the meter **210** while retaining particles behind strainer retainer **220**. The strainer retainer **220** is positioned between the meter **210** and the meter inlet portion **350** inside the meter cavity **450**. The bottom plate **150** is attached to the bottom of the device housing **110** with plate screws **160*a,b,c,d*** and has the plastic liner **240** and the meter gasket **230** between the device housing **110** and the bottom plate **150**. In this embodiment, the water supply valve **170** and the meter **210** are substantially in line between the inlet **310** and the outlet **320**, as previously defined. The meter gasket **215** seals the interface between the metering outlet **213** and the meter outlet standoff **480**.

As illustrated in FIG. **26**, the media channel pathway **2610** extends from the valve cavity **905** to the valve outlet portion **340**. The media channel pathway **2610** includes the media channel **520**, media channel relief **530**, valve cover media channel **830**, solenoid chamber **940**, and the valve cavity media channel **840**. The valve orifice cylinder **280** is placed inside the valve cover media channel **830**. The action of the solenoid **270** either prevents or allows water flow through the media channel pathway **2610**. The valve orifice cylinder **280** provides the interface with the interface portion **1140** of the plunger **1130**. The valve orifice cylinder **280** is chosen of an appropriate size to prevent excessive fluid flow, as excessive fluid flow will cause the diaphragm assembly **260** to lift away from the beveled edge **550** quickly.

In the current embodiment, the water supply valve **170** is a pilot operated valve. A pilot operated valve is a valve that experiences large-scale operation occurring naturally as a result of a small change in the pilot. As such, small amounts of energy can be used to control large-scale changes as the pilot changes. In the current embodiment, the pilot-operated valve is a diaphragm valve.

In use, the valve meter device **100** may assume one of two states: an "on" or "open" state and an "off" or "closed" state. A "trickle" or "reduced flow" state may be substituted for the "off" or "closed" state in various embodiments. The valve meter device **100** may be configured to assume either of the

two possible states. The states correspond to the positioning of the water supply valve **170**.

The valve meter device **100** will typically be in the open state allowing a maximum, or near maximum, flow rate of water that is allowed to flow through the valve meter device **100**. In the current embodiment, maximum flow rate is about 25 gallons per minute, although other maximum flow rates are possible in accord with this disclosure. When the valve meter device **100** is in the open state, the water supply valve **170** is open. When the water supply valve **170** is open, which occurs when the diaphragm **1230** is substantially lifted away from the beveled edge **550** (as seen in FIG. **25**), the solenoid **270** is in the open position and the interface portion **1140** of the plunger **1130** is actuated away from the valve orifice cylinder **280**, as seen in FIG. **26**.

With reference to FIG. **25**, water travels through the valve meter device **100** originating from a water source and entering in inlet **310**. Water is permitted to travel through the inlet opening **612**, into the inlet neck **622**, and to the horizontal portion **610**. When water reaches the intersection of the horizontal portion **610** and vertical portion **620**, water is directed vertically into the vertical portion **620** by water pressure. Water exits the vertical portion **620** by flowing over the beveled edge **550**. Water fills the valve transition portion **670** and—as will be described in more detail later—the valve cavity **905** and media channel pathway **2610**. Water exits the valve portion **265** via the valve outlet portion **340** and enters the meter inlet portion **350**. Water then enters and fills the meter cavity **450**. Pressure forces water into the metering inlet **212**, through the meter **210**, and out of the metering outlet **213** to the meter outlet portion **360** and outlet **320**. Once the water exits the outlet **320**, the water flows through the downstream piping system and, ultimately, to the user terminal.

The water passing through the meter **210** moves the nutating disc **2110** causing the meter magnet **2130** to rotate. The rotation of the meter magnet **2130** causes the register **2220** to log the motion, leading to a measurement of water usage and a readout of water usage from the register **2220**.

The register circuit **2910** configured to log the readout of water usage at preset timing intervals may be included with one embodiment of the valve meter device **100**. In the current embodiment, the register circuit **2910** remains in a low power mode for the majority of its operating life. Low power, as used in this disclosure, means that the register circuit **2910** is using a very small amount of power when compared to the normal operating mode. This is commonly referred to as being in a "sleep mode." The register circuit **2910** "wakes up" at preset timing intervals to read the register **2220** and log the readout. In the current embodiment, the wireless communication unit circuit **2925** is connected with the register circuit **2910** via wires **2360**. The wireless communication unit circuit **2925** obtains the log of the register circuit **2910** and transmits the log to a remotely located communicator at preset timing intervals. The preset timing interval of the wireless communication unit **2310** may or may not be the same preset timing interval as that of the register circuit **2910**. In alternative embodiments, a separate register circuit **2910** may not be necessary if the wireless communication unit **2310** is capable of directly determining the measurement of water usage of the register **2220**.

The water supply valve **170** is configured in the open state when the interface portion **1140** is lifted away from the valve orifice cylinder **280** because the solenoid **270** is in the open position, as seen in FIG. **26**. The valve cavity media channel **840** provides a water pressure link between the solenoid chamber **940** and the valve cavity **905** such that the water pressure in the valve cavity **905** will be the same as the water pressure in the solenoid chamber **940**. When the solenoid **270** is in the open position, the plunger **1130** is lifted so that the valve orifice cylinder **280** is open to the valve cover media channel **830**. When the valve orifice cylinder **280** is uncovered, water is allowed to flow from the solenoid chamber **940** through the valve cover media channel **830** into the media channel **520** and further into the valve outlet portion **340**. Therefore, the water pressure in the valve cavity **905** is substantially the same as the water pressure in the media channel **520**, the solenoid chamber **940**, the media channel **520**, and the valve outlet portion **340**. Thus, the diaphragm **1230** has no pressure behind it to close the water supply valve **170**. The water supply valve **170** remains open. Although the current embodiment has the valve orifice cylinder **280** located on the valve cover media channel **830** such that there is a pressure link between the valve cavity **905** and the solenoid chamber **940**, the valve orifice cylinder **280** may be located within the valve cavity media channel **840** in alternative embodiments. Other locations for the valve orifice are also contemplated by the current disclosure.

Changing the valve meter device **100** to a closed state requires the water supply valve **170** to be changed to closed. Where a trickle state is included, the water supply valve must be changed to a trickle state, which may be the same as the closed state in various embodiments. This is accomplished by operation of the plunger **1130** moving into a closed position having the interface portion **1140** contacting the valve orifice cylinder **280**, which provides a water-tight seal over the valve cover media channel **830**. In the closed state, the valve meter device **100** allows no water flow through. In the trickle state, the valve meter device **100** allows minimal water flow through. In the current embodiment, minimal water flow is greater than zero gallons per minute and less than about 2 gallons per minute, although other minimal flow rates are possible in accord with this disclosure. FIG. **27** displays the water supply valve **170** in the dynamic state between the open and closed states. In this dynamic state, the solenoid **270** is in the closed position but the diaphragm assembly **260** is has not traveled to the beveled edge **550**. In the current embodiment, the water supply valve **170** is a diaphragm valve with a pressure-controlled pilot operation. To move the valve meter device **100** into the closed state, the solenoid **270** is engaged, or "thrown," and closed onto the valve orifice cylinder **280**. This closes or "severs" the media channel pathway **2610**. Water flow is blocked from the solenoid chamber **940** to the valve cover media channel **830** as well as to the media channel **520** and media channel relief **530** thereby isolating the solenoid chamber **940**, the valve cavity media channel **840**, and the valve cavity **905** as one water pressure pool. Thus, the closing of the solenoid **270** is the pilot operation that triggers the dynamic state of the water supply valve **170**. FIG. **28** displays the water supply valve **170** in the closed state, wherein the interface portion **1140** of the plunger **1130** is in contact with the valve orifice cylinder **280** and the diaphragm assembly **260** has traveled and contacted the beveled edge **550**, sealing the water supply valve **170**.

After the solenoid **270** is closed or thrown, water may no longer exit the valve cavity **905**, so the valve cavity **905** no longer has media pressure behind it. Spring force provided from the diaphragm **1230** or from the optional spring **250** forces the diaphragm assembly **260** down toward the valve inlet portion **330** of the device housing **110**. The spring **250** is optional because, depending on the configuration of the diaphragm **1230**, the diaphragm **1230** may already he biased toward closing the water supply valve **170** without the spring **250**. As the diaphragm assembly **260** moves toward the valve inlet portion **330**, some of the water flowing through the valve

portion **265** will leak through the water leak passthroughs **1260**, through the strainer **1240**, through the water leak hole **1740**, and into the valve cavity **905**. The increased volume of water in the valve cavity **905** creates increased pressure in the valve cavity **905**. The increased pressure in the valve cavity **905** is applied to the entire surface of the diaphragm **1230** because the valve cavity **905** extends across the entire diaphragm **1230**. This increased pressure applied over the entire diaphragm **1230** further biases the diaphragm assembly **260** in the direction of the valve inlet portion **330**.

The increased bias causes the diaphragm assembly **260** to travel toward the valve inlet portion **330**, eventually seating the bottom of the inner flat portion **1440** of the diaphragm **1230** onto the beveled edge **550** of the top edge portion **640** of the valve inlet portion **330**. When the diaphragm **1230** seats onto the beveled edge **550**, the water supply valve **170** is in the closed state.

Once the diaphragm **1230** has seated, water pressure from the valve inlet portion **330** equalizes with water pressure in the valve cavity **905** because water can pass into the valve cavity **905** through the valve cone **1210** of the diaphragm assembly **260** but cannot exit the valve cavity **905** down the media channel pathway **2610**. With equalized pressure, the water supply valve **170** remains in the closed state because the cross-section of the valve inlet portion **330** provides a smaller surface area over which to apply pressure to the diaphragm **1230** than the surface area of the diaphragm **1230** that interfaces with the valve cavity **905**. With the same pressure, a smaller surface area over which the pressure is applied produces a smaller force than the same pressure applied to a larger surface area. The result is a net downward force on the diaphragm **1230**, maintaining the water supply valve **170** in the closed state. The trickle state is accomplished by placing the diaphragm **1230** in the same position as the diaphragm **1230** is placed in the closed state. However, in the trickle state, a small amount of water is allowed to bypass the water supply valve **170** via a leak passageway (not shown) in the diaphragm **1230** or a bypass channel (not shown) from the valve inlet portion **330** to the valve outlet portion **340**. The bypass channel or leak passageway may be a small bore leading from the valve inlet portion **330** to the valve outlet portion **340** and may be placed in the vertical portion **620**, for example. The bore would be small enough that a significant amount of water would not flow through the bore. A sealing valve may allow selective flow through the bore.

To reopen the water supply valve **170**, the solenoid **270** is actuated so that the interface portion **1140** lifts away from the valve orifice cylinder **280**, opening the media channel pathway **2610**. Opening the media channel pathway **2610** establishes a pressure link between all of the components of the media channel pathway **2610**, including the valve cavity **905**, the valve cavity media channel **840**, the solenoid chamber **940**, the valve cover media channel **830**, the media channel relief **530**, and the media channel **520**. When the pressure in the valve cavity **905** is reduced, the downward force on the diaphragm **1230** and the diaphragm assembly **260** is also reduced. The pressure in the valve inlet portion **330** provides greater upward force on the bottom of the diaphragm **1230** than the downward force on the top of the diaphragm **1230**, which may be provided by the spring **250** or by the inherent bias of the diaphragm **1230**. The result is a lifting of the diaphragm assembly **260**, thereby opening the water supply valve **170**.

The solenoid **270** may be engaged or lifted by manual operation, by electronic actuation, or by remote control. In one embodiment, the wireless communication unit **2310** is capable of receiving electrical signals for the solenoid **270** to control its operation. Actuation of the plunger **1130** in the current embodiment is performed by a solenoid **270**, which is a latching solenoid in the current embodiment. A latching solenoid is a solenoid **270** that latches in place. A latching solenoid does not utilize energy once it has achieved its desired position but does use energy to change positions. However, this actuation can be performed via a number of mechanical or electromechanical interfaces, including stepper motors, DC motors, non-latching solenoids, electromagnets and other electromagnetic devices, and spring assemblies, among others. This embodiment would allow a remotely located communicator to control operation of the water supply valve **170**, allowing the water supply valve **170** to be changed to an open or closed state from a remote location.

The wireless communication unit **2310** may include a wireless communication unit circuit **2925**. The wireless communication unit circuit **2925** may be configured to log the status of the solenoid **270**. For example, the communication unit circuit **2925** may log whether the solenoid **270** is in the open or closed position. Because operation of the solenoid **270** controls the water supply valve **170**, the status of the solenoid **270** will be substantially the same as the status of the water supply valve **170** unless the water supply valve **170** is non-functioning or the water supply valve **170** is in a dynamic state between open and closed.

In a further embodiment, a valve monitoring circuit **2945** may be implemented. The valve monitoring circuit **2945** monitors the status of the water supply valve **170** by monitoring whether the solenoid **270** should be in the open position or in the closed position. If the solenoid **270** is logged to be in the closed position and the readings from the register circuit **2910** continue to change, the wireless communication unit **2310** may send a distress signal to alert the remotely located communicator that the water supply valve **170** of the valve meter device **100** is not operational. Alternatively, wireless communication unit **2310** may keep track of the expected state of the water supply valve **170** and determine if water flow is detected by the register assembly **2210**.

The wireless communication unit **2310** and register circuit **2910** may be powered by a battery **2430**. Each may have its own battery or each may be powered by the same battery. In the current embodiment, the solenoid **270**, the wireless communication unit **2310**, and the register circuit **2910** are all powered by the battery **2430**. In the current embodiment, the battery **2430** is a lithium thionyl battery. In the current embodiment, the battery **2430** is capable of providing a nominal voltage of 3.6 VDC and a minimum voltage of 2.9 VDC with minimum available current of 300 mA. Other embodiments may include other electrical specifications.

In some embodiments, indicator lights (not shown) may be included. A valve indicator may be included to indicate the nominal state of the water supply valve **170**. A mechanical remote valve indicator may also be included to ensure that actuation of the water supply valve **170** has commenced. Other remote and local indication mechanisms may also be used as well.

FIGS. **30** and **31** display diagrams of control logic for the circuits of the valve meter device **100**. The operation of the register circuit **2910** is described by FIG. **30**. In operation, the register circuit **2910** awakens on timed intervals as shown in step **3020**. The value of the register **2220** is read in step **3030** and compared to previous register values in step **3040**. The register circuit **2910** is returned to a sleep state in step **3050**. The register circuit **2910** sleeps for a preset timing interval before repeating.

FIG. 31 displays a diagram of the control logic of wireless communication unit circuit 2925, including interaction with the optional valve monitoring circuit 2945. The wireless communication unit awakens at present timing intervals as shown in step 3120. In the current embodiment, the register circuit 2910 awakens, reads the register value, and compares the current value with the previous value as shown by step 3010. Following the step 3010, the wireless communication unit circuit 2925 stores the compared value from the register circuit 2910, as shown in step 3130, and sends that compared value to a remotely located communicator as shown with step 3140. Although the compared value from the register circuit 2910 is stored in memory in the current embodiment, the storing step need not be implemented in all embodiments, and in alternative embodiments, the storing step may be included with the remotely located communicator instead of with the wireless communication unit circuit 2925.

Included in this embodiment is the valve monitoring circuit 2945. However, the valve monitoring circuit 2945 may not be present in all embodiments, as depicted by step 3142 in FIG. 31. If a valve monitoring circuit 2945 is present, the status of the water supply valve 170 is logged by determining whether the solenoid 270 is in the open or closed position, represented by step 3155. The valve monitoring circuit 2945 also logs the most recent compared value from the register circuit 2910 as shown in step 3165. If the status of the water supply valve 170 is open or on, the circuit bypasses further logic, as represented by step 3172, and proceeds to allow the wireless communication unit circuit 2925 to sleep as in step 3150. If the status of the water supply valve 170 is closed or off, the valve monitoring circuit 2945 includes further steps. As represented by step 3175, the most recent compared value of the register circuit 2910 is compared to prior values of the register circuit 2910 that are logged in memory of the valve monitoring circuit 2945. If the most recent compared value of the register circuit 2910 is substantially different from prior compared values of the register circuit 2910, shown by step 3182, the valve monitoring circuit 2945 is configured to send a distress signal from the wireless communication unit 2310 to the remotely located communicator, represented by step 3185. The valve monitoring circuit 2945 then continues to sleep the wireless communication unit circuit 2925, as shown by step 3150, which sleeps for a preset timing interval before repeating.

One should note that conditional language, such as, among others, "can," "could," "might," or "may," unless specifically stated otherwise, or otherwise understood within the context as used, is generally intended to convey that certain embodiments include, while other embodiments do not include, certain features, elements, and/or steps. Unless stated otherwise, it should not be assumed that multiple features, embodiments, solutions, or elements address the same or related problems or needs. Thus, such conditional language is not generally intended to imply that features, elements, and/or steps are in any way required for one or more particular embodiments or that one or more particular embodiments necessarily include logic for deciding, with or without user input or prompting, whether these features, elements, and/or steps are included or are to be performed in any particular embodiment.

It should be emphasized that the above-described embodiments are merely possible examples of implementations, merely set forth for a clear understanding of the principles of the present disclosure. Any physical properties described above should be understood as representing one of many possible embodiments, and alternate implementations are included depending on the functionality involved, as would be understood by those reasonably skilled in the art of the present disclosure. Many variations and modifications may be made to the above-described embodiment(s) without departing substantially from the spirit and principles of the present disclosure. Further, the scope of the present disclosure is intended to cover any and all combinations and sub-combinations of all elements, features, and aspects discussed above. All such modifications and variations are intended to be included herein within the scope of the present disclosure, and all possible claims to individual aspects or combinations of elements or steps are intended to be supported by the present disclosure.

The invention claimed is:

1. An assembly comprising:

a housing, the housing defining at least one inlet opening, at least one outlet opening, and a channel connecting the at least one inlet opening and the at least one outlet opening, the at least one inlet opening having an inlet end and the at least one outlet opening having an outlet end, there being a linear distance between the inlet end and the outlet end, the linear distance being no greater than a standard water meter lay-length;

a water meter positioned in the channel, the water meter configured to monitor a flow of water through the assembly;

a valve in communication with the channel and configured to control the flow of water through the assembly;

a communications device configured to send signals to a remotely located communicator; and

a valve monitoring circuit, wherein the valve monitoring circuit includes:

logic configured to monitor a state of the valve, the state including an open state and at least one of a closed state and a trickle state; and

logic configured to determine if water is flowing through the meter;

wherein the signals include a distress signal if at least one of a first condition and a second condition are met,

wherein the first condition is that water is flowing through the meter when the state of the valve is in the closed state, and

wherein the second condition is that water is flowing through the meter in excess of a predetermined amount when the state of the valve is in the trickle state.

2. The assembly of claim 1, wherein the communication device is connected to the assembly by an electrical connection.

3. The assembly of claim 1, wherein the communication device is configured to receive signals from a remotely located communicator.

4. The assembly of claim 1, wherein the communication device is a wireless communication unit.

5. The assembly of claim 1, wherein the valve is configurable to assume one of at least two of three states, the states including an open state, a closed state, and a trickle state.

6. The assembly of claim 1, wherein the standard water meter lay-length is seven and one-half inches.

7. The assembly of claim 1, wherein at least a portion of the valve resides in the housing.

8. The assembly of claim 1, wherein the valve is a pilot operated valve.

9. The assembly of claim 1, wherein the valve is a diaphragm valve.

10. An assembly for use with a water meter, the assembly comprising:

a housing including a body portion, at least one inlet, and at least one outlet, the inlet having an inlet end and the

outlet having an outlet end, the housing including an outer surface and an inner surface, the inner surface shaped to receive the water meter and defining an internal cavity of the body portion, the internal cavity of the body portion including an inlet and an outlet;

a valve in sealable communication with the inner surface, wherein the valve and the water meter are placed about in line between the at least one inlet and the at least one outlet;

a communications device configured to send signals to a remotely located communicator; and

a valve monitoring circuit, wherein the valve monitoring circuit includes:

logic configured to monitor a state of the valve, the state including an open state and at least one of a closed state and a trickle state; and

logic configured to determine if water is flowing through the meter;

wherein the signals include a distress signal if at least one of a first condition and a second condition are met,

wherein the first condition is that water is flowing through the meter when the state of the valve is in the closed state, and

wherein the second condition is that water is flowing through the meter in excess of a predetermined amount when the state of the valve is in the trickle state.

11. The assembly of claim **10**, wherein the internal cavity inlet portion defines a substantially rectangular opening.

12. The assembly of claim **10**, wherein the communication device is a wireless communication unit.

13. The assembly of claim **10**, wherein the valve is a pilot operated valve.

14. The assembly of claim **10**, wherein the housing is made of a non-ferrous material.

15. An assembly comprising:

a housing including at least one inlet and at least one outlet, the housing defining at least one inlet opening, at least one outlet opening, and a channel substantially connecting the at least one inlet opening and the at least one outlet opening, the at least one inlet opening having an inlet end and the at least one outlet opening having an outlet end, there being a linear distance between the inlet end and the outlet end, the linear distance being no greater than a standard water meter lay-length;

a water meter residing in the housing and in communication with the channel;

a valve in communication with the channel, wherein the valve and the meter is placed in line between the inlet end and the outlet end;

a communications device configured to send signals to a remotely located communicator; and

a valve monitoring circuit, wherein the valve monitoring circuit includes:

logic configured to monitor a state of the valve, the state including an open state and at least one of a closed state and a trickle state; and

logic configured to determine if water is flowing through the meter;

wherein the signals include a distress signal if at least one of a first condition and a second condition are met,

wherein the first condition is that water is flowing through the meter when the state of the valve is in the closed state, and

wherein the second condition is that water is flowing through the meter in excess of a predetermined amount when the state of the valve is in the trickle state.

16. The assembly of claim **15**, wherein the valve is controlled by valve control signals.

17. The assembly of claim **15**, wherein the standard water meter lay-length is seven and one-half inches.

18. The assembly of claim **15**, wherein the valve is a pilot operated valve.

19. The assembly of claim **15**, wherein the housing is made of a non-ferrous material.

20. A method of monitoring a valve meter assembly comprising the steps of:

monitoring a flow of water through a valve meter assembly;

monitoring a status of a water supply valve, the status describing the position of the water supply valve, the status including at least one of open, closed and trickle;

transmitting signals with a communication device;

measuring a first flow of water value through the valve meter assembly;

measuring a second flow of water value through the valve meter assembly;

comparing the first flow of water value and the second flow of water value; and

transmitting a distress signal if the first flow of water value and the second flow of water value are not the same value and the status of the water supply valve is one of closed and trickle.

* * * * *

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Blackwell et al.

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(45) **Date of Patent: Feb. 4, 2014**

(54) **METHOD AND SYSTEM FOR PROVIDING WEB-ENABLED CELLULAR ACCESS TO METER READING DATA**

(75) Inventors: **Morrice D. Blackwell**, Mequon, WI (US); **Randall L. Schultz**, Fredonia, WI (US); **Yarum Locker**, Givat Shmuel (IL)

(73) Assignee: **Badger Meter, Inc.**, Milwaukee, WI (US)

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(52) **U.S. Cl.**
USPC **455/414.1**

(58) **Field of Classification Search**
USPC 340/870.02, 870.03; 455/414.1
See application file for complete search history.

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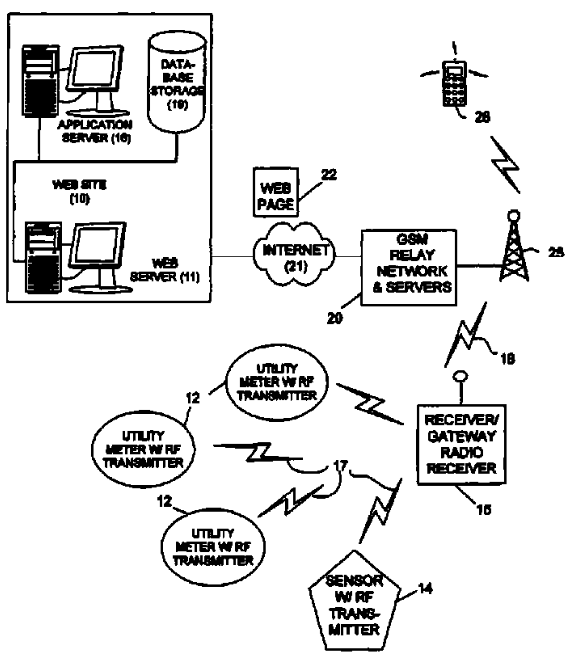
Primary Examiner — Nathan Mitchell
(74) *Attorney, Agent, or Firm* — Boyle Fredrickson, S.C.

(57) **ABSTRACT**

A method and a system for collection of meter readings from meter reading and transmitting devices (**12**, **14**) and for viewing on a web-enabled wireless communication device (**28**) comprises addressing at least one receiver (**15**) through the Internet (**21**) and obtaining a data file of meter data for a plurality of meter reading devices (**12**, **14**) that have previously communicated with the receiver (**15**). The receiver (**15**) can then re-transmit the meter data through a wide area network such as the Internet (**21**) to a web site (**10**) operated by an organization marketing AMR systems. The meter data is then accessed and displayed at a customer demonstration site using a handheld wireless smart phone (**28**) which receives a web page (**22**) that is reduced in size for transmission through the cellular network to the smart phone (**28**).

19 Claims, 2 Drawing Sheets



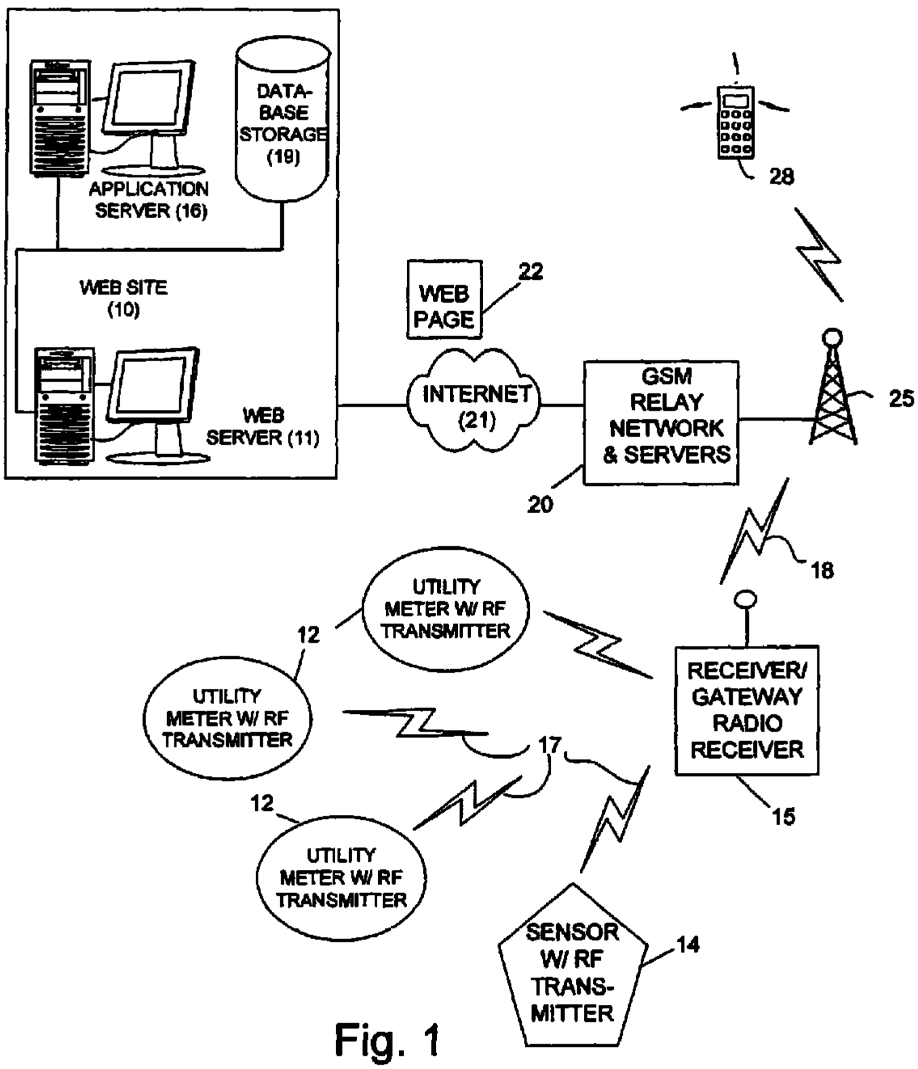

DATA-BASE STORAGE (19)
APPLICATION SERVER (16)
WEB SITE (10)
WEB SERVER (11)
WEB PAGE
22
INTERNET (21)
GSM RELAY NETWORK & SERVERS
20
28
25
18
RECEIVER/ GATEWAY RADIO RECEIVER
15
UTILITY METER W/ RF TRANSMITTER
12
UTILITY METER W/ RF TRANSMITTER
12
UTILITY METER W/ RF TRANSMITTER
17
SENSOR W/ RF TRANS-MITTER
14

Fig. 1

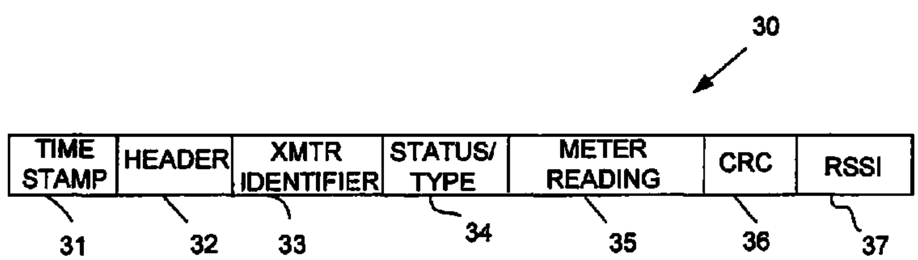

30
TIME STAMP
HEADER
XMTR IDENTIFIER
STATUS/ TYPE
METER READING
CRC
RSSI
31
32
33
34
35
36
37

Fig. 2

METHOD AND SYSTEM FOR PROVIDING WEB-ENABLED CELLULAR ACCESS TO METER READING DATA

TECHNICAL FIELD

This invention relates to automatic meter reading (AMR) systems using radio transmitters and receivers for collecting meter data signals over a geographical area, such as a municipality or utility district.

DESCRIPTION OF THE BACKGROUND ART

Fixed network (non-mobile) AMR (automatic meter reading) systems typically involve meters equipped with radio transmitters operating in a local area network with radio receivers, often mounted on a rooftop or a utility pole. The receivers also sometimes operate as gateways, for collecting meter data from the transmitters and then transmitting the meter data through a second network to a central office. The meter data is transmitted from the receivers or gateways to the central office for processing into customer statements of account. Typically, there is at least a network communications computer and an applications computer at the central office of the local utility, although various systems at the collection end are possible and are known in the art.

In the prior art, installing an AMR system included the setting up of a central office data collection system and a database for the meter data.

In the marketing of AMR systems, it would be advantageous to demonstrate the collection of meter reading data before actual installation of the central office data collection system. Prospective customers could then see how the system would work prior to contracting for installation of a large system.

SUMMARY OF THE INVENTION

The invention provides a method and a system for collection of meter readings from meter reading and transmitting devices and for viewing meter data on a web-enabled wireless communication device.

The method comprises addressing at least one receiver through a wide area network, preferably the Internet, to obtain meter data from at least one and usually a plurality of meter reading devices that have previously communicated with the receiver. The receiver can then re-transmit the meter data to a web site operated by the organization marketing AMR systems. The data is then be accessed from a customer demonstration site, preferably using a wireless communication device.

The method and system of the present invention can run on a web site that can be reached through a GSM or other cellular network. The method of the invention further includes reading a file of meter data in the form of an HTML web page, which is then modified for viewing on a web-enabled handheld wireless communication device.

The wireless communication device is preferably a web-enabled wireless communication device, such as a Blackberry web-enabled cellular phone, another web-enabled cellular phone or personal digital assistant (PDA). In alternative embodiments, the web-enabled wireless communication device can also be a laptop with wireless Internet capability, but a handheld wireless processor-based device is considered advantageous and is strongly preferred for convenience and portability.

The invention provides a demonstration tool that can be operated at a customer demonstration site by a sales person as part of a customer presentation without requiring assistance from engineering personnel as practiced in the prior art. The use of a Web application on a web-enabled telephone simulates collection of data at a utility collection site. This will demonstrate the capabilities of the AMR-networked system prior to purchase by utility customers and installation at their premises.

Other objects and advantages of the invention, besides those discussed above, will be apparent to those of ordinary skill in the art from the description of the preferred embodiments which follows. In the description, reference is made to the accompanying drawings, which form a part hereof, and which illustrate examples of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a schematic of a fixed-network AMR system for collecting meter data from transmissions from meter data reading devices and making the data available through a web-enabled cellular device; and

FIG. **2** is a data map of data received from the meter reading devices.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring to FIG. **1**, a network gateway receiver **15** is installed on a roof top (not shown) or on a utility pole (not shown). In this preferred embodiment, the utility is water, however, in other embodiments the utility can be gas or electricity.

A plurality of meter reading devices **12** each include a utility meter, a transducer and an RF (radio frequency) transmitter. In this example, the units **12** can be meter reading and transmitting units commercially offered under the Orion® trademark or the Galaxy® trademark by the assignee of the present invention. These meter reading devices **12** transmit radio frequency (RF) signals **17** to the receiver **15** to form a local area wireless network. It should be understood that there is typically more than one receiver **15** in a network, although only one is illustrated in FIG. **1**. Sometimes the receiver **15** is also referred to as a "gateway" because it interfaces between the local area wireless network and another longer range network **21**. Alternatively, the meter reading devices **14** may be sensors for sensing other types of conditions at the utility meter or in supply links connected to the utility meters. These sensors may be connected to Orion® or Galaxy® radio transmitters to transmit status data to the receiver **15**.

The meter reading devices **12**, **14** read meter data and certain alarm/condition status data from the meters. As used herein, the term "meter data" should be understood to include either utility consumption data or condition status data, or both. Condition status data includes leak detection data, tamper data and shut-off valve data and other types of data concerning meter operation besides actual utility consumption data.

The devices **12**, **14** transmit data-encoded RF signals over low power RF frequencies either in the non FCC-licensed ISM (Industrial-Scientific-Medical) band from 902 MHz to 928 MHz or in the FCC-licensed frequencies such as 150-200 Mhz, 325 MHz, 433.92 MHz or from 450 to 470 MHz. The meter data transmitters **12**, **14** transmit to an RF receiver **15**, which in this case is a Galaxy® receiver offered by the assignee of the present invention. The receiver **15** is provided with wireless capability to re-broadcast transmissions to a

GSM cellular tower 25, a GSM network 20 and the Internet 21 to a GSM-networked web site 10. This web site 10 includes a web server 11 for handling communications in both directions through the Internet 21, and an applications server 16 for handling the content of pages for communication and display through the Internet 21. The applications server 16 also stores and accesses data in a database stored in a database storage unit 19. The database stores a receiver network address, a list of transmitting devices 12, 14 served by the receiver 15, a history of readings for the transmitting devices 12, 14 and a history of readings from the receiver 15. It should be mentioned here that many architectures are available for web sites using additional servers and these are within the scope of the present invention.

The web site 10 will store the meter data in web pages 22 that can be accessed at an Internet Protocol (IP) addresses having the format XXX.YY.ZZZ, where X, Y and Z are individual numbers from "0" to "9" or preferably at a domain name/URL address of the form http://www.(name).(domain)/ where "(name)" is the site identifier and "(domain)" is a domain such as .com or .(country).

These web pages can be accessed through a GSM relay network and servers 20 that can convert HTML pages to web pages of a type that can be displayed on the visual display portion of a wireless handheld device, such as a BlackBerry™ smart phone, as disclosed in U.S. Pat. No. 7,302,637, issued Nov. 27, 2007, the disclosure of which is incorporated here by reference.

The web site 10 will have its own distinctive domain name or IP address. It can be maintained by the marketing organization or a hosted by a third party on behalf of the marketing organization.

An application program is provided on the handheld wireless device 28 to access the web site 10 and obtain a reduced size version of the web page 22 through the GSM relay network and servers 20.

When accessed by a user of the handheld device 28, a log-in screen will appear prompting the user to enter a user name and a password. After logging in, the user will have an option to select a "Monitor" mode or a "Data View" mode. A search screen will also be available to allow the user to find the data for a specific transmitter. The web site 10 is addressed and a web page 22 of data is transmitted from the web site 10 to the web-enabled wireless device 28 through the Internet 21 and is converted to a reduced size web page as the web page 22 is transferred through the GSM relay network and servers 20. On the handheld device 28, a reduced size "Monitor" web page 22 will display the last transmissions that were received by the receiver/gateway 15 from the meter/transmitters 12. The data displayed on the "Monitor" web page will include the transmitter number, the time of reception and an indication of signal strength (by a graphic representation of the RSSI). By selecting a line on the screen display of the web-enabled wireless device, the user can cause a display of a history of daily transmissions received from a specific transmitter.

The data is preferably displayed in a WAP format supported by web-enabled smart phone devices such as a BlackBerry™ smart phone. Each line of data contains data received from one of the transmitters. FIG. 2 shows a map of each line of data 30 in a web page 22. There is a first item of data 31 which is a time stamp for the individual meter reading device 12, 14. Next, there is a header 32. This is followed by an item of data 33 representing the identifier, such as a serial number of the transmitter which corresponds to each meter reading device 12, 14. Next, there is a status or type item of data 34 which identifies one of several types of meter reading devices 12, such as an RTR® pulse register/transmitter type, an ADE® digital encoder type, or gas meter registers, or other designations for completely electronic registers. This is followed by the actual meter data or status condition data, as represented by item 35. This is followed by a CRC item of data 36, which is a cyclic redundancy code or error checking code computed from the data earlier in line of data. Finally, a radio signal strength indicator (RSSI) item of data 37 is provided from each meter reading device 12, 14 for radio network diagnostics purposes.

As seen from the above description, the invention provides for easier demonstration of the data collection abilities of an AMR system on a handheld wireless processor-based device, thereby saving labor and installation cost and providing ease of use to the marketing organization and the utility customer.

This has been a description of the preferred embodiments, but it will be apparent to those of ordinary skill in the art that variations may be made in the details of these specific embodiments without departing from the scope and spirit of the present invention, and that such variations are intended to be encompassed by the following claims.

We claim:

1. A method for collection of meter data through a wide area network from at least one receiver communicating in a local network with at least one meter reading device in a geographic area, the method comprising:

receiving data, including utility consumption data and condition status data, through the wide area network at a web site from the receiver that includes meter data from at least one meter reading device that has previously communicated with the receiver;

storing the meter data at the web site; and

accessing the meter data at the web site using a wireless communication device at a customer demonstration site and displaying the condition status data on a display portion of the wireless communication device, wherein the condition status data includes at least one of leak detection data, tamper data, radio signal strength, and shut-off valve data.

2. The method of claim 1, wherein the meter data is accessed by an application program on the wireless communication device that displays the meter data as a reduced size web page.

3. The method of claim 2, wherein the wireless communication is a handheld web-enabled phone device.

4. The method of claim 3, wherein the handheld web-enabled phone device communicates through a GSM cellular network.

5. The method of claim 2, wherein the meter data is received at the web site as an HTML web page and is stored at the web site.

6. The method of claim 5, wherein the wide area network is the Internet.

7. The method of claim 1, wherein the meter reading devices include devices for reading condition status data related to a meter or to supply links connected to the meter, and wherein the meter data includes condition status data.

8. A system for displaying meter reading data collected from at least one reading device in a geographic area, the system comprising: a web site for receiving and storing a data file through a wide area network from the at least one receiver that includes meter reading data, including utility consumption data and condition status data, from a plurality of meter reading devices that have previously communicated with the receiver; and an application program for a web-enabled cellular phone for displaying condition status data communicated from a web site accessible through a cellular network,

wherein the condition status data includes at least one of leak detection data, tamper data, radio signal strength, and shut-off valve data.

9. The system of claim **8**, wherein the application program displays the meter data as a reduced size web page on a display portion of the web-enabled cellular phone.

10. The system of claim **8**, wherein web-enabled cellular phone communicates through a GSM cellular network.

11. The system of claim **8**, wherein the meter data is received at the web site as an HTML web page and is stored at the web site.

12. The system of claim **11**, wherein the wide area network is the Internet.

13. The system of claim **8**, wherein the meter reading devices include devices for reading condition status data related to a meter or to supply links connected to the meter, and wherein the meter data includes condition status data.

14. A method for collection of meter data through a wide area network from at least one receiver communicating in a local network with at least one meter reading device in a geographic area, the method comprising:

receiving data through the wide area network at a web site from the receiver that includes meter data from at least one meter reading device that has previously communicated with the receiver;

storing the meter data at the web site;

receiving a request to display the meter data at the web site from a wireless communication device; and

transmitting the meter data for dig lay on a display portion of the wireless communication device, wherein the meter data includes a plurality of meter readings for at least one meter reading device that have been transmitted at a defined time interval,

wherein receiving a request to display the meter data at the web site from a wireless communication device includes selection of a link displayed on a web page specific to the at least one meter reading device.

15. The method of claim **14**, wherein the meter data is displayed on the display portion as a reduced size web page.

16. A method for collection of meter data through a wide area network from at least one receiver communicating in a local network with at least one meter reading device in a geographic area, the method comprising:

receiving data through the wide area network at a web site from the receiver that includes meter data from at least one meter reading device that has previously communicated with the receiver;

storing the meter data at the web site;

receiving a request to display the meter data at the web site from a wireless communication device; and

transmitting the meter data for display on a display portion of the wireless communication device, wherein the meter data includes a plurality of meter readings for at least one meter reading device that have been transmitted at a defined time interval, wherein the meter data includes an indication of signal strength.

17. The method of claim **16**, wherein the indication of signal strength includes an indication of signal strength for each defined time interval.

18. The method of claim **17**, wherein the defined time interval is daily.

19. A method for collection of meter data through a wide area network from at least one receiver communicating in a local network with at least one meter reading device in a geographic area the method comprising:

receiving data through the wide area network at a web site from the receiver that includes meter data from at least one meter reading device that has previously communicated with the receiver;

storing the meter data at the web site;

receiving a request to display the meter data at the web site from a wireless communication device; and

transmitting the meter data for display on a display portion of the wireless communication device, wherein the meter data includes a plurality of meter readings for at least one meter reading device that have been transmitted at a defined time interval,

wherein the at least one meter reading device includes a least one device for reading condition status data related to a meter or to supply links connected to the meter, and wherein the meter data includes condition status data.

* * * * *

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Olson et al.

(10) **Patent No.: US 8,878,690 B2**
(45) **Date of Patent: Nov. 4, 2014**

(54) **AMR TRANSMITTER AND METHOD USING MULTIPLE RADIO MESSAGES**

(75) Inventors: **John A. Olson**, Brookfield, WI (US); **Ronald D. Benson**, Colgate, WI (US)

(73) Assignee: **Badger Meter, Inc.**, Milwaukee, WI (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 1199 days.

(21) Appl. No.: **12/489,590**

(22) Filed: **Jun. 23, 2009**

(65) **Prior Publication Data**

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G08C 15/06 (2006.01)
G08B 21/00 (2006.01)
G01D 4/00 (2006.01)

(52) **U.S. Cl.**
CPC ***G01D 4/004*** (2013.01); *Y02B 90/242* (2013.01); *Y04S 20/325* (2013.01); *Y02B 90/243* (2013.01); ***G01D 4/006*** (2013.01); *Y04S 20/322* (2013.01)
USPC **340/870.02**; 340/870.16

(58) **Field of Classification Search**
CPC G01F 15/06; G01D 4/004; Y02B 90/243; Y02B 90/242
USPC 340/870.02
See application file for complete search history.

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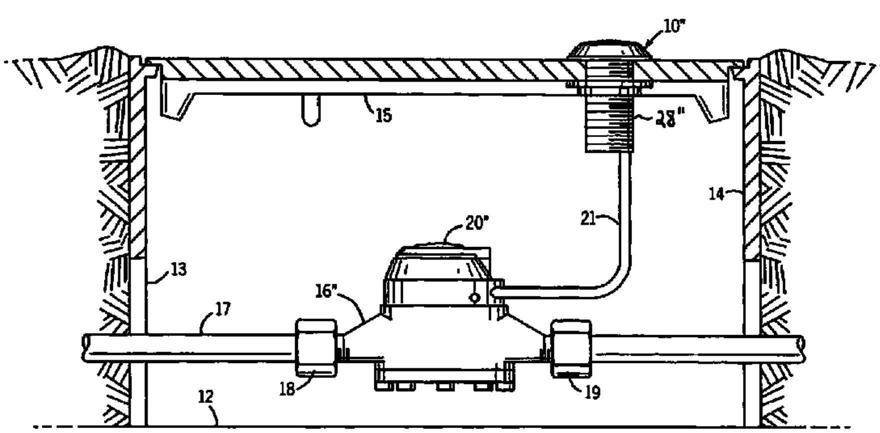
Primary Examiner — Mohammad Ghayour
Assistant Examiner — Jerold Murphy
(74) *Attorney, Agent, or Firm* — Boyle Fredrickson, S.C.

(57) **ABSTRACT**

The invention provides a method and several types of devices for converting meter reading signals into data messages including a first message (**40**) having meter data (**44**) representing consumption of a utility, and meter diagnostic status data (**43**), and a second message (**60**) having meter reverse flow data (**63-65**) and meter diagnostic data (**66**) particular to an electronic flow meter, and receiving said first message (**40**) and said second message (**60**) and converting first message and said second message to radio frequency signals (**25**) and transmitting said radio frequency signals (**25**) to a receiver (**22**, **24**).

24 Claims, 8 Drawing Sheets



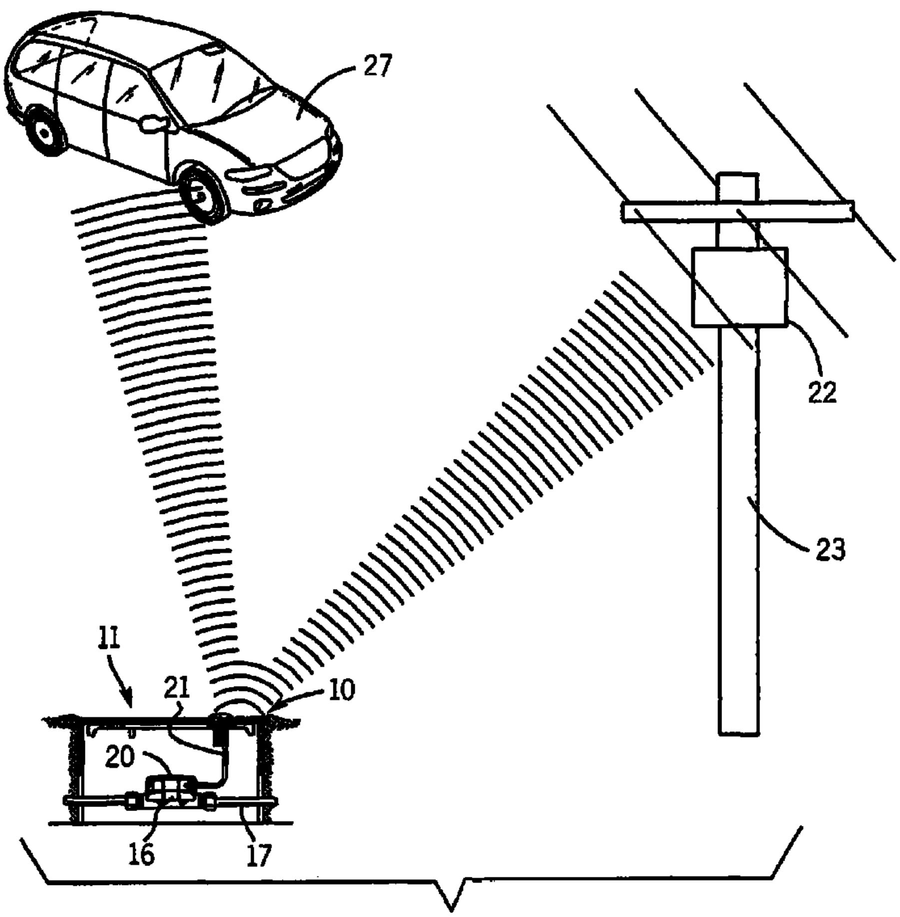


FIG. 1

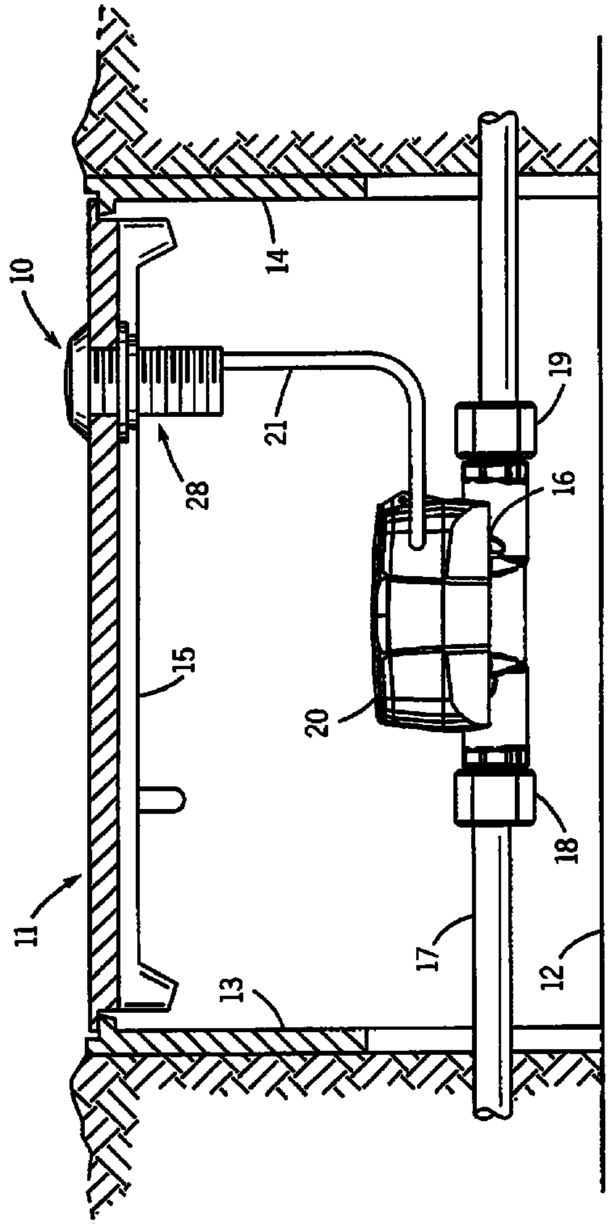


FIG. 2

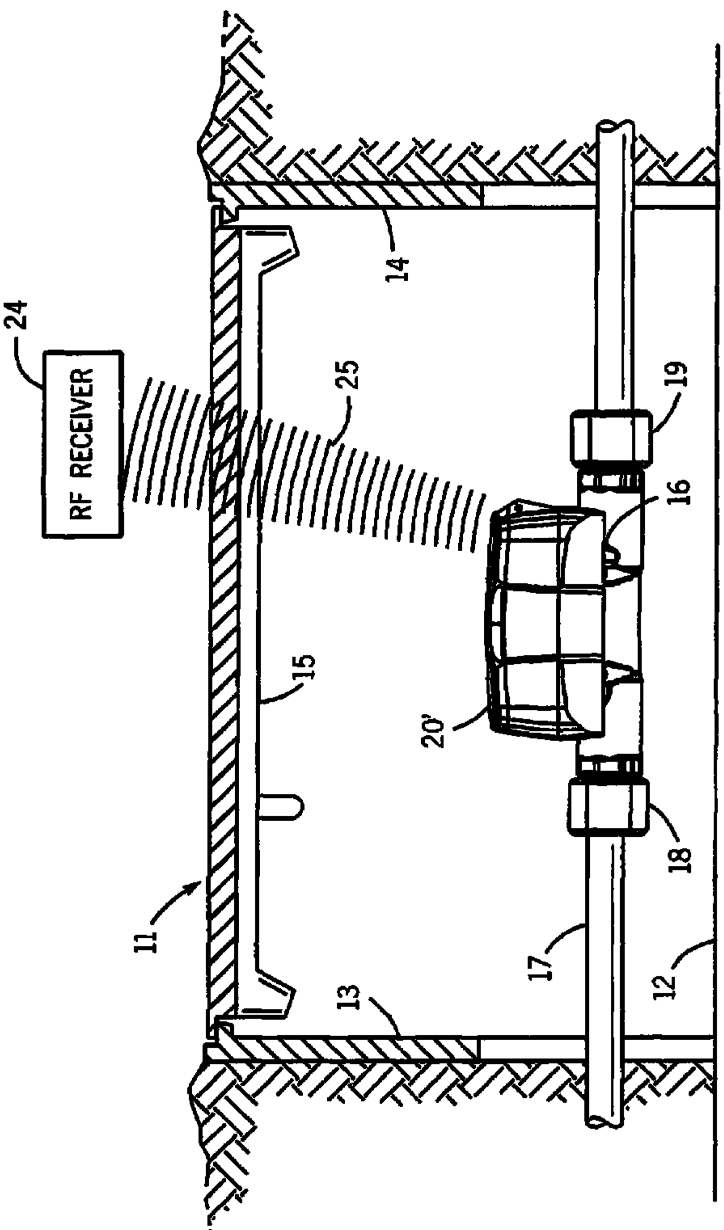


FIG. 3

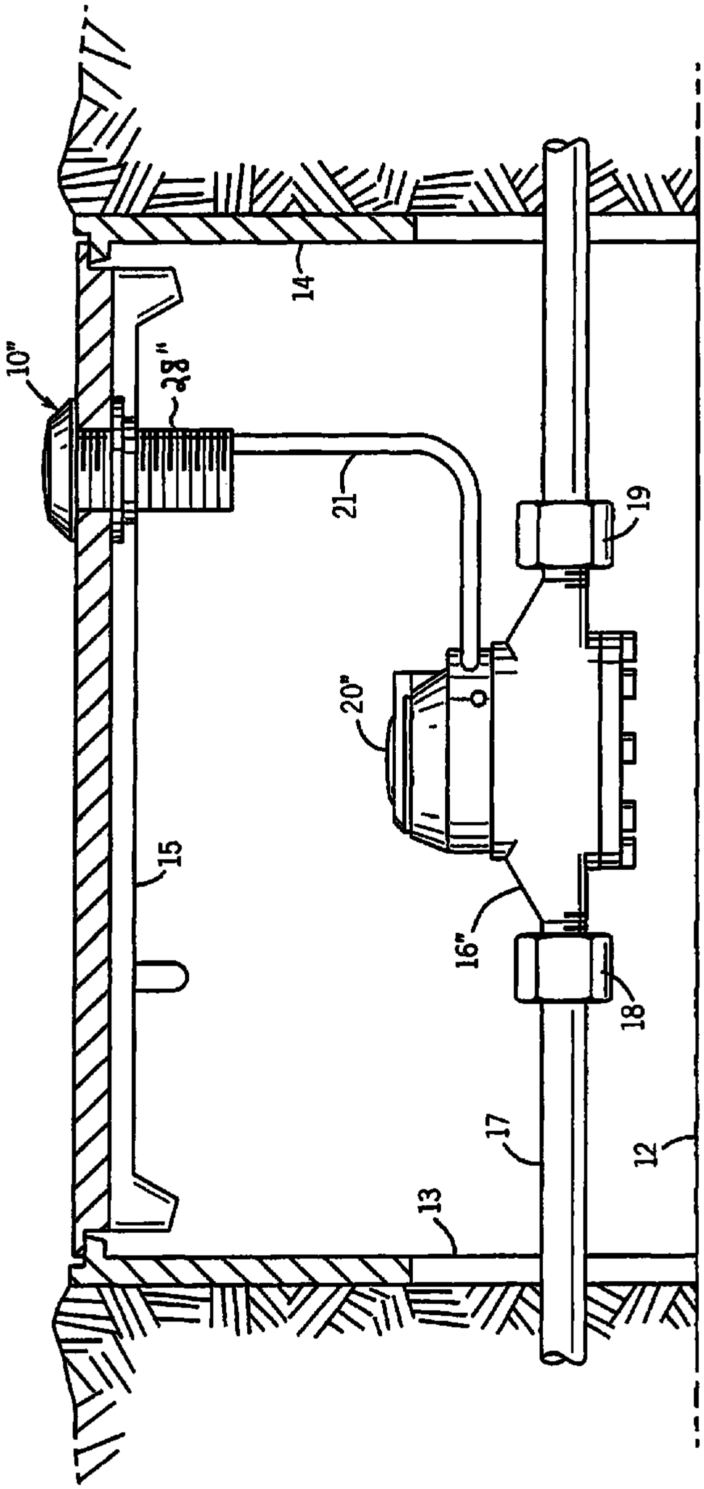


FIG. 4

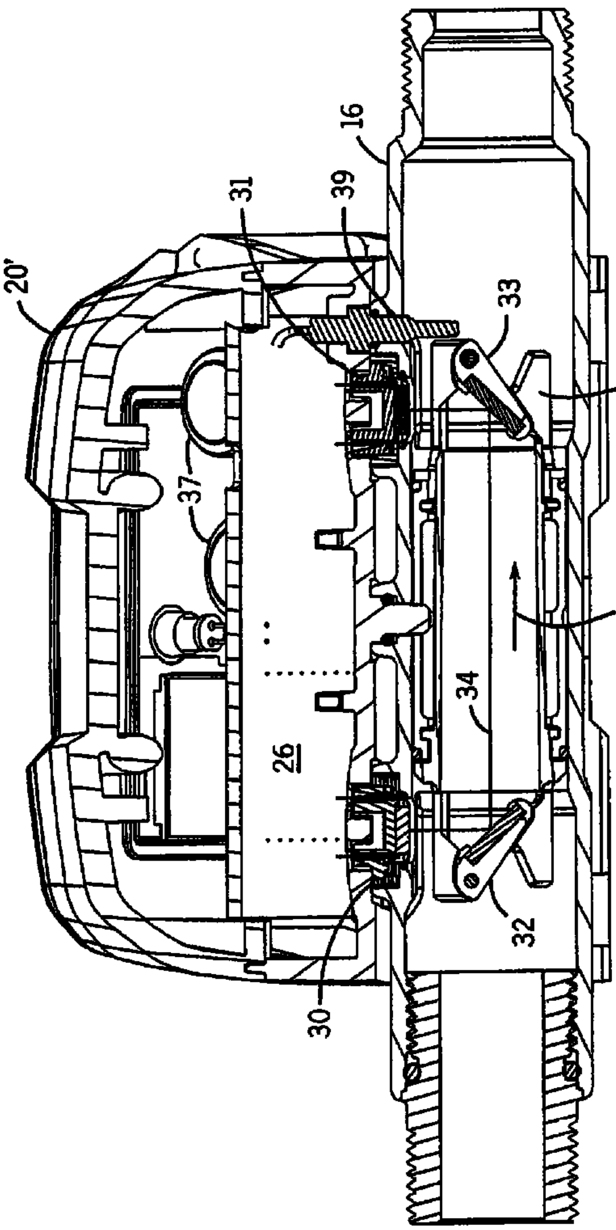


FIG. 5

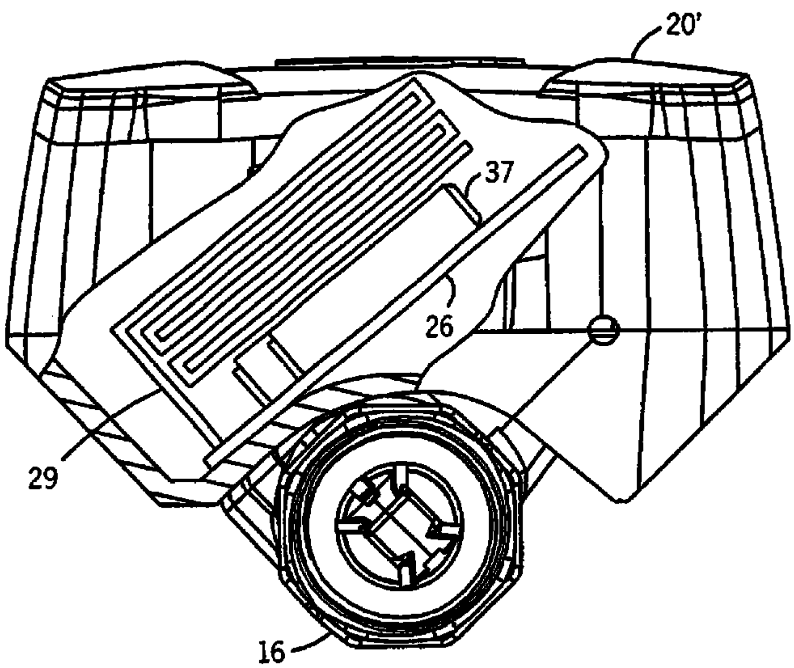


FIG. 6

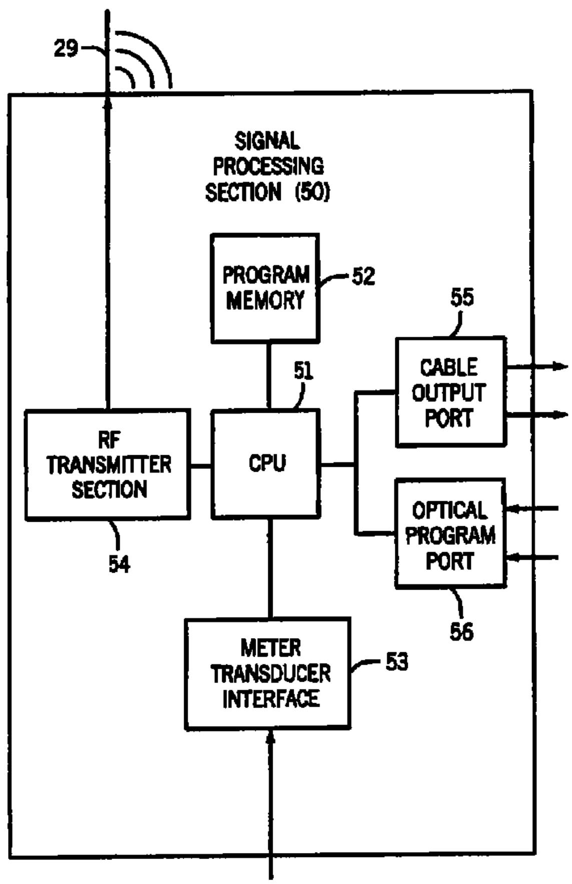

29
SIGNAL PROCESSING SECTION (50)
PROGRAM MEMORY
52
55
CABLE OUTPUT PORT
51
RF TRANSMITTER SECTION
CPU
OPTICAL PROGRAM PORT
54
56
METER TRANSDUCER INTERFACE
53

FIG. 7

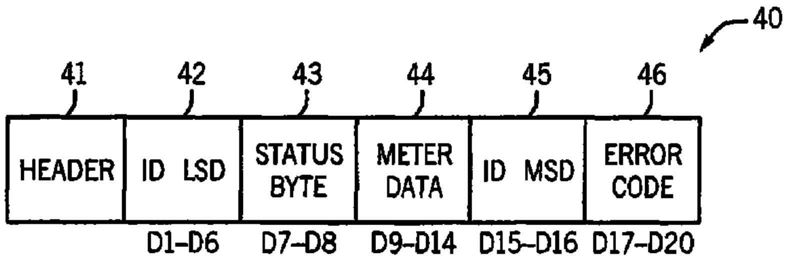


FIG. 8

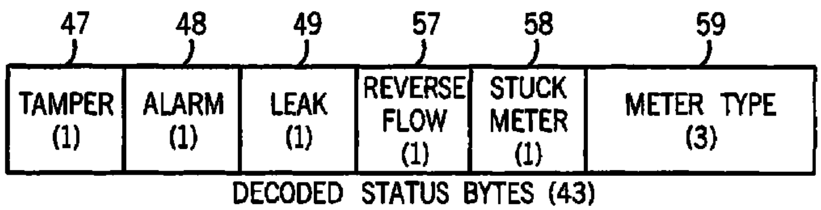


FIG. 9

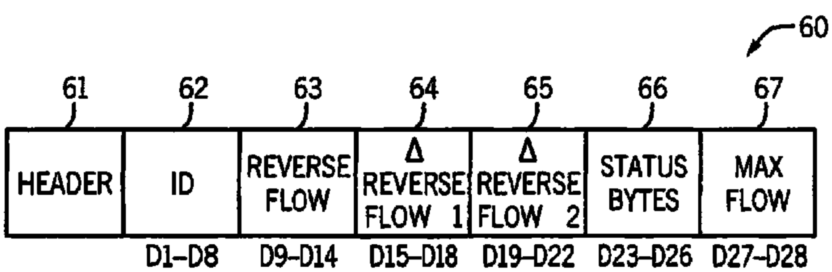


FIG. 10

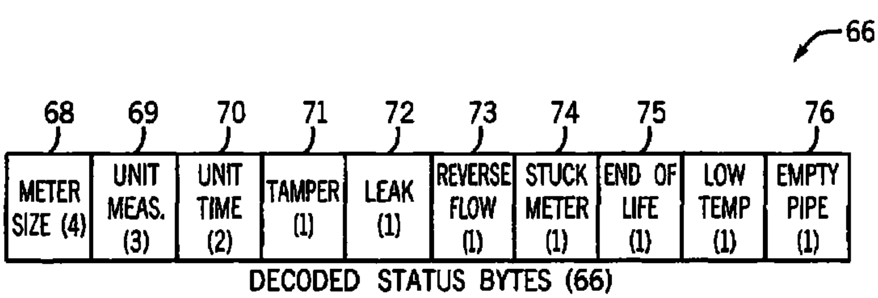


FIG. 11

AMR TRANSMITTER AND METHOD USING MULTIPLE RADIO MESSAGES

TECHNICAL FIELD

This invention relates to automatic meter reading (AMR) systems that include an electronic meter or meter register and a network for collecting utility metering data.

DESCRIPTION OF THE BACKGROUND ART

Recently, electronic meter registers have begun to appear in utility metering applications. An example of a separate electronic meter register is disclosed in Olson, U.S. Pat. No. 6,611,769. An example of an electronic meter register integrated in one housing with a mechanical meter is disclosed in Lazar et al., U.S. Pat. No. 7,412,882.

Traditionally, ultrasonic and acoustic type meters have been used for measuring industrial and wastewater flows. Examples of such meters are disclosed in Lee, U.S. Pat. No. 3,935,735; Lee et al., U.S. Pat. No. 4,052,896 and Vander Heyden et al., U.S. Pat. No. 4,633,719. Such meters depend on signals impinging upon particles in the flow stream, Doppler methods and time-of-travel characteristics to measure the flow. European Patent Publication 1 493 998 A2, published Jun. 8, 2004, discloses an ultrasonic flow meter for utility usage.

The use of some types of electronic meters, such as ultrasonic types, fluidic oscillatory types and electromagnetic sensing meters, has been limited due to elements of cost. With advances in the design and construction of these devices, it may now be possible to meet marketplace pricing constraints.

Electronic meters have not previously been in widespread use in utility applications in the United States due to cost factors. As raw material costs and manufacturing costs are rapidly increasing at this time, there is a now a cost advantage to converting mechanical-based metering systems to electronic metering systems. Also, electronic meters are well-suited for use in AMR systems. Electronic meters provide greater accuracy than some other types of known utility meters. And, electronic meters are well adapted to flows with particles included.

Electronic meters and meter registers may be able to handle certain data that is particular to electronic meters such as reverse flow data, empty pipe data and end-of-life data. This, however, requires improvements in network communication protocols to handle the additional data.

SUMMARY OF THE INVENTION

In one aspect, the invention relates to a method and circuitry for communicating metering data in a pair of related messages to a receiver. The first of two messages includes a transmitter ID number, utility consumption data, and diagnostic data for conventional conditions such as, for example, a tamper indication, a leakage indication, and a stuck meter indication. A second message is provided to add reverse flow data and diagnostic data, particular to an electronic meter, such as an empty pipe indication, and an end of life indication.

In a further aspect of the invention, status data are added to the first message to indicate the presence of reverse flow data and diagnostic data, such as empty pipe, low temperature and end-of-life in the second message.

In a further aspect of this invention, the second message can be transmitted less frequently than the first message by an order of magnitude, or the interval can be extended for the purpose of conserving the life of one or more batteries.

The invention also provides diagnostic data and profiling data for reverse flow conditions over the last seven days and the last twenty-four (24) hours.

The invention is provided in three physical embodiments, one embodiment which fully integrates a meter, a meter register and a radio transmitter in one housing, and two other embodiments in which meter data is output through a data port from the meter register to a separate transmitter assembly, which can be mounted to a pit lid.

Other objects and advantages of the invention, besides those discussed above, will be apparent to those of ordinary skill in the art from the description of the preferred embodiments which follows. In the description, reference is made to the accompanying drawings, which form a part hereof, and which illustrate examples of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a perspective view of an AMR system, illustrating a mobile receiver in a drive-by vehicle and a fixed receiver for receiving transmissions from a transmitter associated with a utility meter;

FIG. **2** is a side view in elevation of a meter assembly and a separate transmitter assembly installed in a subsurface pit enclosure;

FIG. **3** is a side view in elevation of an integrated meter, meter transducer and transmitter assembly installed in a subsurface pit enclosure;

FIG. **4** is a side view in elevation of a conventional water meter with a meter register and a transmitter assembly of the present invention installed in a subsurface pit enclosure;

FIG. **5** is a sectional view of the meter assembly of the present invention of FIG. **2**;

FIG. **6** is an end view of the meter assembly of FIG. **2** with parts of the housing broken away for a view of the interior;

FIG. **7** is a block diagram of a signal processing section within the meter of the present invention of FIG. **4**;

FIGS. **8-9** are data maps of a first message transmitted by the transmitter portion of FIGS. **2-4** to a receiver; and

FIGS. **10-11** are data maps of a second message transmitted by the transmitter portion of FIGS. **2-4** to a receiver.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring to FIGS. **1** and **2**, in this example, the invention is incorporated in a water meter assembly **16**, **20**, and a radio transmitter assembly **10** disposed in a subsurface pit enclosure **11** and connected by a cable **21**. The pit enclosure **11** is typically made of metal, concrete, plastic or other materials with a lid **15** which is removable to open the enclosure **11** for access. The pit enclosure **11** is located along the route of water supply pipe **17**. The housing assembly **16**, **20** includes a lower, tubular housing **16** for housing the water metering elements and for withstanding water pressure, which is connected in the water supply line **17** by coupling nuts **18** and **19** (FIG. **2**). An upper housing **20** for a water meter register, and in some other embodiments, a transmitter, is positioned on top of the lower housing **16**. This upper housing **20** is preferably made of plastic, such as polystyrene, ASA Luran or an equivalent non-metallic material. A visual display of a type known in the art would be seen from the top of the upper housing **20**. In recent years, the meter register has included a transducer for converting: i) mechanical movements, ii) movements of a magnet or iii) electrical meter signals to electrical signals of a type known in the art for signaling units of consumption of a utility.

As further seen in FIGS. **2** and **4**, in a "remote version" of the present invention, a shielded cable **21** connects the electronics in the meter register housing **20, 20"** to a transmitter assembly **10, 10"** which is housed in a tubular transmitter housing **28, 28"**, preferably of a plastic material, such as polystryrene, ASA Luran or an equivalent non-metallic material. The transmitter housing **28, 28"** hangs down from the pit lid **15** and includes its own battery, as is known in the art. The transducer electronics in the meter register housing **20, 20"** transmits electrical signals representing units of consumption of a utility to the transmitter assembly **10, 10"**, which incorporates meter data and other data in messages encoded for transmission through a radio network.

FIG. **2** provides a version in which the meter and meter register are integrated, but where the transmitter assembly **10** is contained in a separate housing. FIG. **4** represents the traditional configuration of a separate meter register **20"** mounted on a water meter housing **16"** with a separate transmitter assembly **10"**.

In a fully "integrated version" of the invention seen in FIG. **3**, a housing **20'** encloses both meter register and transmitter formed on a circuit board **26** with an antenna **29** for transmitting signals directly through the pit lid **15** to a radio signal receiver **24**. In this version, the pit lid **15** is made of a non-RF-interference material, for example, plastic, concrete, or other materials that will not significantly change the direction of, or attenuate, RF signals.

The transmitter assemblies **10, 10", 26** communicate via RF signals with a receiver **24** which can be a mobile receiver in a vehicle **27** seen in FIG. **1**. The transmitter assemblies **10, 10", 26** each transmit radio frequency signals encoded with messages and meter data, as will be further described below in relation to FIGS. **8-11**. The meter data is collected from various customer locations and transmitted to a central office for processing for billing purposes.

In the present invention, the transmitter assemblies **10, 10", 26** also communicate via RF signals with a fixed receiver **22** installed on a utility pole **23** seen in FIG. 1, within a range of up to one thousand feet of the transmitter unit **10**. The transmitter assembly **10, 10", 26** transmits electronic messages, including meter data, as will be further described below in relation to FIGS. **8-11**.

Referring to FIG. **5**, in the integrated meter, meter register and transmitter (FIG. **3** version), the meter housing **16** is made of brass or another suitable material, preferably lead-free, to withstand water pressures. Inside the housing **16** is a plastic metering insert **38** positioned in the conduit **16** and supporting two mirrors **32, 33** at minus forty-five degrees and plus forty-five degrees, respectively, relative to vertical. The assembly also includes two ultrasonic transducers **30, 31**, a temperature sensor **39**, a signal processing section, **50**, and one or more batteries **37**. A first ultrasonic signal will be transmitted through one of the transducers **30** downward, to reflect off one of the mirrors **32** at ninety degrees, to travel through the flow stream **35** as an ultrasonic signal parallel to the flow stream and the meter housing **16**, which is shaped like a pipe. The signal will then reflect off the second mirror **33** at ninety degrees and be detected by the second ultrasonic transducer **31** and converted to an input to the signal processing section **50** in FIG. **7**. A second signal is then transmitted in a reverse direction through second one of the transducers **31**, downward to reflect off the second one of the mirrors **33** at ninety degrees to travel through the flow stream **35** opposite the direction of flow **35** and parallel to the direction of flow and the conduit **16**. The signal will then reflect off the first-mentioned mirror **32** at ninety degrees and be detected by the first ultrasonic transducer **30** and input to the signal processing section **50** in FIG. **7**. A temperature sensor **39** is also positioned with one end projecting into the flow stream **35**.

Referring to FIG. **7**, the housing **20'** in FIGS. **3** and **5**, encloses an electrical signal processing section **50** typically formed on a circuit board **26** and including a microelectronic CPU **51** operating according to a control program of program instructions stored in a program memory **52**, which may be internal to the CPU **51**. The memory **52** is flash memory that can be altered with a special programming unit, which communicates with the transmitter through an optical I/O data port **56**, preferably utilizing the IrDa (infrared frequency) protocol. Data profiling data for reverse flow is read through this optical I/O data port **56** as well. This can be stored in a non-volatile memory external to the CPU **51**.

As further seen in FIG. **7**, the CPU **51** receives signals from an ultrasonic transducer interface **53**. This section **53** can receive the ultrasonic signals **34** after conversion by the transducers **30, 31**, to eventually produce data signals at a logic level of power, such as 3.6 dc volts, for digital circuitry. The CPU **51** produces metering data in messages, which are converted to radio frequency (RF) signals by an RF transmitter section **54** that modulates signals for transmission. These signals can then be signaled directly through an antenna **29** (FIGS. **6** and **7**) to an RF receiver, represented generally by block **24** in FIG. **3**, provided that the pit lid **15** is not made of metal so as to interfere with the radio frequency signals. The message data contained in the RF transmissions is mapped in FIGS. **8-11**.

In the embodiments in FIGS. **2** and **4**, a meter transducer section (not illustrated) in the meter register housing **20, 20"** would transmit data representing units of utility consumption through a cable output port and through the cable **21**, to respective transmitter assemblies **10, 10"** seen in FIGS. **2** and **4** for conversion to RF signals and transmission to a radio receiver **24** seen in FIG. **1**. In these embodiments, the transmitter assemblies **10, 10"** would include a signal processing section of a type seen in FIG. **7**, including a CPU, a program memory, an RF transmitter section and an antenna to convert the meter data to radio frequency signals according to a message protocol. The information in the radio messages, as transmitted from the transmitter assemblies **10, 10"**, would be organized as illustrated in FIGS. **8-11**.

The radio signals can be transmitted from the AMR transmitter in several modes of operation in a one-way AMR network. Although the invention is disclosed in one example, in a one-way network, the invention could also be applied in a two-way communication network, where each radio transmitter described herein would be included as one portion of a transceiver. Drive-by vehicles **27** (FIG. **1**) will be able to read the transmitter signal and collect meter readings. This type of system uses a battery for power and this mode of transmission provides long battery life using small batteries. This signal may be read by fixed receivers **22** provided they are not too far from the transmitter.

To reach fixed location receivers **22** (FIG. **1**), it is desirable to provide a transmission utilizing a higher power level than the prior art low power methods used for communicating with drive-by receivers. In the present invention, this is accomplished by sending out a frequency-hopping spread-spectrum (FHSS) signal over twenty-five channels. Various time periods can be observed in sending out the two messages, and the second message may be sent out less frequently than the first message.

FIGS. **8-11** show the data in the two messages referred to more generally above. The messages contain data for implementing various alarm conditions, including a reverse flow alarm, a potential leak alarm, a stuck meter condition (no

usage for 30 days), a tamper alarm, an empty pipe alarm, a low temperature alarm and an end-of-life notification. The reverse flow alarm, the empty pipe condition and the end-of-life notification are conditions which are particularly related to electronic flow meters. The low temperature condition is a feature of the ultrasonic flow meter that is available and is sensed with the addition of a temperature sensor **39** to the meter housing assembly **16**, **20** as seen in FIG. **4**.

As seen in FIG. **8**, the first message **40** includes a header **41** of forty-eight (48) bits, a data field and an error code field in the form of 120 bits comprising twenty (20) hexadecimal digits. The first six hexadecimal digits, D1-D6, provide digits of a transmitter identification number. The next two hexadecimal digits, D7-D8, provide status data **43** seen in more detail in FIG. **9**. This is followed by six hexadecimal digits, D9-D14, of meter data representing consumption of the utility by the customer. This is followed by two more hexadecimal digits, D15-D16, providing the most significant digits of a transmitter identification number. This is followed by four more hexadecimal digits, D17-D20, providing an error checking code, preferably a cyclic redundancy code (CRC).

Referring to FIG. **9**, the status byte **43** includes status bits indicating presence of alarm data in a following message for the tamper alarm **47**, other alarms **48** such as empty pipe, low temperature (3 degrees C. or below) or end-of-life, potential leak alarm **49** (no usage 24 hours), reverse flow alarm **57** or stuck meter (no usage) alarm **58**. The last three bits **59** indicate a meter encoder type, such as RTR, ADE or gas, which are types known from the commercial products of the assignee.

As seen in FIG. **10**, the second message **60** also includes a header **61** of forty-eight (48) bits, a data field and an error code field in the form of 136 bits comprising thirty-four (20) four-bit hexadecimal digits. The first eight hexadecimal digits, D1-D8, provide four bytes of a transmitter identification number. The next six hexadecimal digits, D9-D14, provide reverse flow data **63**. This is followed by four hexadecimal digits, D15-D18, of "Δ reverse flow" data **64** in the last twenty-four (24) hours. This is followed by four more hexadecimal digits, D19-D22 providing of "Δ reverse flow" data **65** in the last seven (7) days. This is followed by four more four more hexadecimal digits, D23-D26, providing two bytes of status data **66** seen in more detail FIG. **11**. This is followed by two more hexadecimal digits, D27-D28, providing data for max flow rate and by four more hexadecimal digits D29-D32 (not shown in FIG. **9**) providing an error checking code, preferably a cyclic redundancy code (CRC).

FIG. **11** shows the details of the two status bytes **66** in which meter size is defined by four bits **68**, a unit of measure is defined by the next three bits **69**, units of time are defined by the next two bits **70**, and indicators are provided for the following alarms: tamper **71**, leak **72**, reverse flow **73**, stuck meter **74** (no usage for 30 days), end-of-life **75** and low temperature **76**.

It should be noted that the alarm status bits **47-49** and **57-58** in the first message in FIG. **8** indicate the presence of actual alarm data in the second message. It should now be apparent how the first message and second message contribute to increasing the diagnostic data available in the two messages due to the capabilities of electronic flow meters, including an ultrasonic flow meter. This provides advantages in diagnosing operating conditions, which have not been known before the invention.

This has been a description of the preferred embodiments, but it will be apparent to those of ordinary skill in the art that variations may be made in the details of these specific embodiments without departing from the scope and spirit of the present invention. For example, although the preferred embodiment uses electronic signals to develop a meter reading, it will be apparent that the same messaging can be applied to other types of electronic meters as well as to conventional electromechanical meters and that such variations are intended to be encompassed by the following claims, unless specifically excluded.

We claim:

1. Apparatus for use in transmitting radio messages in an automatic fluid meter reading network, the apparatus comprising:

a processing circuit for converting fluid meter reading signals into messages, including a first message, having utility consumption data, and meter alarm status data, the meter alarm status data including a reverse flow alarm status signal, and a second message having meter reverse flow consumption data corresponding to the reverse flow alarm status signal in the first data message and meter diagnostic data corresponding to the alarm status data in the first message;

and transmitter circuitry configured for receiving said first message and said second message from the processing circuit, the transmitter circuitry converting said first message and said second message into radio frequency signals and transmitting said radio frequency signals to an external receiver.

2. The apparatus as recited in claim **1**, further comprising an ultrasonic flow meter, the apparatus being housed in one housing assembly that can be installed in a flow stream within a pipe in which signals are transmitted by the ultrasonic flow meter through the flow stream to measure flow.

3. The apparatus as recited in claim **1**, further comprising an ultrasonic flow meter and wherein the electronic flow meter and the processing circuit for converting meter reading signals into messages, are housed in a housing assembly that can be installed in a flow stream within a pipe, and wherein the transmitter circuitry is housed in a separate housing.

4. The apparatus as recited in claim **2** or **3**, wherein the assembly further comprises a low temperature sensor disposed in the flow stream and wherein the diagnostic data includes a low temperature event signal.

5. The apparatus of claim **1**, wherein the processing circuit and the transmitter circuitry are enclosed in a transmitter housing separate from a meter and a meter register that provides signals representing units of utility consumption to the transmitter housing.

6. The apparatus as recited in claim **1**, wherein the diagnostic data includes at least one of: empty pipe data and battery end-of-life data.

7. The apparatus as recited in claim **1**, wherein the diagnostic data includes reverse flow consumption data indicating reverse flow conditions over a last seven days and includes data indicating reverse flow conditions over a last twenty-four hours.

8. The apparatus as recited in claim **1**, wherein the second message is transmitted less frequently than the first message.

9. The apparatus as recited in claim **1**, wherein the first message and the second message are transmitted as frequency-hopping spread-spectrum signals.

10. The apparatus as recited in claim **1**, wherein the first message and the message are transmitted by circuitry comprising a single transmitter.

11. The apparatus as recited in claim **1**, further comprising an optical data port communicating with circuitry for converting meter reading signals, the optical data port providing access to an external device for reading reverse flow profiling data for a defined time period from the processing circuit.

12. A method of transmitting radio frequency signals representing utility metering data, the method comprising:

in a utility fluid meter interface device, converting meter reading signals from a flow sensing device into message data, said message data including a first message having utility consumption data and meter alarm status data, the meter alarm status data including a reverse flow alarm status signal, and a second message having meter reverse flow consumption data corresponding to the reverse flow alarm status signal of the first message and meter diagnostic data particular to an electronic flow meter corresponding to the meter alarm status data of the first message; and

receiving said message data in said first message and said second message and converting said first message and said second message to radio frequency signals and transmitting said radio frequency signals to a receiver.

13. The method as recited in claim 12, wherein the electronic flow meter is more particularly an ultrasonic flow meter in which signals are transmitted through a flow stream to measure flow and the method further comprising sensing temperature in the flow stream and wherein the diagnostic data includes a low temperature event signal.

14. The method as recited in claim 12, wherein the diagnostic data includes at least one of empty pipe data and battery end-of-life data.

15. The method as recited in claim 12, wherein the radio signals carrying the second message are transmitted less frequently than the radio signals carrying the first message to conserve power consumption in a battery-powered utility fluid meter interface device.

16. The method as recited in claim 12, wherein the second message is transmitted less frequently than the first message.

17. The method as recited in claim 12, wherein the meter reverse flow consumption data includes data indicating reverse flow conditions over a last seven days and includes data indicating reverse flow conditions over a last twenty-four hours.

18. Apparatus for use in transmitting radio messages in an automatic water meter reading network, the apparatus being utilized in a subsurface enclosure outside of any building, and the apparatus comprising:

a processing circuit programmed for executing a control program of instructions for converting meter reading signals into messages, including a first message having utility consumption data and meter alarm status data, the meter alarm status data including a reverse flow alarm, and a second message having meter reverse flow data over at least one defined time period corresponding to the reverse flow alarm of the first message and meter diagnostic data particular to the electronic flow meter including at least one of: empty pipe data and battery end-of-life data corresponding to the meter alarm status data of the first message; and

transmitter circuitry configured for receiving said first message and said second message from the processing circuit, the transmitter circuitry converting said first, message and said second message into radio frequency signals and transmitting said radio frequency signals to an external receiver, and

wherein the apparatus is powered by batteries and wherein the second message is transmitted dependent on the transmission of the first message to conserve power consumption from the batteries.

19. The apparatus as recited in claim 18, further comprising an electronic flow meter, the apparatus being housed in one housing assembly adapted for installation in a flow stream within a pipe.

20. The apparatus as recited in claim 18, further comprising an electronic flow meter and wherein the electronic flow meter, and the processing circuit for converting meter reading signals into messages, are housed in a housing assembly adapted for installation in a flow stream within a pipe, and wherein the transmitter circuitry is housed in a separate housing.

21. The apparatus as recited in claim 19 or 20, wherein the electronic flow meter is more particularly an ultrasonic flow meter, and the assembly further comprises a low temperature sensor disposed in the flow stream and wherein the diagnostic data includes a low temperature event signal.

22. The apparatus as recited in claim 18, wherein the reverse flow data indicates reverse flow conditions over a last seven days and includes data indicating reverse flow conditions over a last twenty-four hours.

23. The apparatus as recited in claim 18, wherein the first message and the second message are transmitted as frequency-hopping spread-spectrum signals.

24. The apparatus as recited in claim 18, further comprising an optical data port communicating with circuitry for converting meter reading signals, the optical data port providing access to an external device for reading reverse flow profiling data for a defined time period from the processing circuit.

* * * * *

US007012546B1

(12) **United States Patent**
Zigdon et al.

(10) **Patent No.: US 7,012,546 B1**
(45) **Date of Patent: Mar. 14, 2006**

(54) **MODULAR WIRELESS FIXED NETWORK FOR WIDE-AREA METERING DATA COLLECTION AND METER MODULE APPARATUS**

(75) Inventors: **Shimon Zigdon**, Netanya (IL); **Carmel Heth**, Grapevine, TX (US)

(73) Assignee: **M&FC Holding, LLC**, Raleigh, NC (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 344 days.

(21) Appl. No.: **10/199,108**

(22) Filed: **Jul. 22, 2002**

Related U.S. Application Data

(63) Continuation-in-part of application No. 09/950,623, filed on Sep. 13, 2001.

(51) **Int. Cl.**
G08B 29/00 (2006.01)

(52) **U.S. Cl.** **340/870.02**; 340/870.01; 370/346

(58) **Field of Classification Search** .... 340/870.01, 340/870.02, 870.12, 825.02; 324/116, 158.1, 324/110, 103 R; 702/62, 61; 370/346; 379/106.03
See application file for complete search history.

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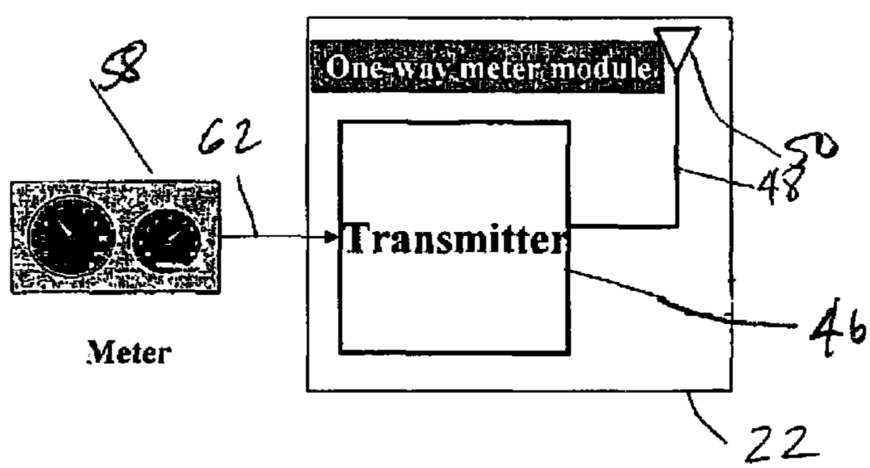
Primary Examiner—Michael Horabik
Assistant Examiner—Hung Dang
(74) *Attorney, Agent, or Firm*—Bacon & Thomas

(57) **ABSTRACT**

A one way direct sequence spread spectrum (DSSS) communications wide-area network is the data collection channel (uplink) of an automatic meter reading (AMR) system, and a paging network, or other suitable communication channel is the optional forward (downlink) channel. The communications network may include one-way meter modules (transmitters) each communicatively coupled to a corresponding electric, gas or water utility meter, and may include two-way meter modules (transceivers) each coupled to such a corresponding utility meter. The meter modules monitor, store, encode and periodically transmit metering data via radio signals (air messages) in an appropriate RF channel. Metering data air messages are collected by a network of receiver Base Stations (BS) and forwarded to a Data Operations Center (DOC), which acts as a metering data gateway. The reception range of each base station is typically over 5 miles in urban areas, allowing sparse infrastructure deployment for a wide variety of metering data collection applications.

13 Claims, 16 Drawing Sheets



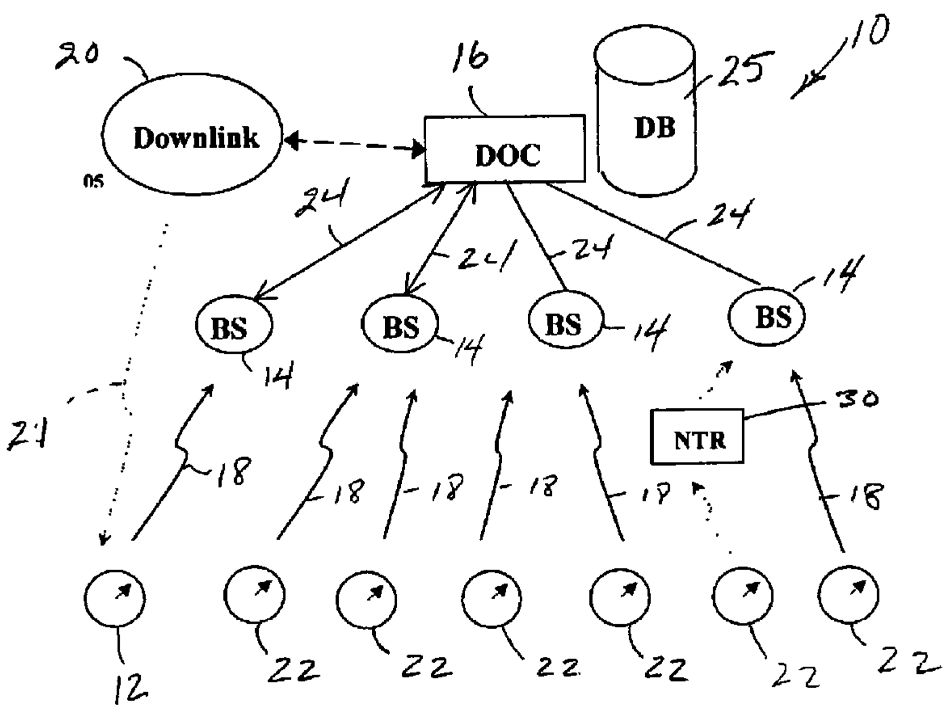

20
Downlink
16
DOC
DB
25
10
24
24
24
24
BS
BS
BS
BS
14
14
14
14
21
18
18
18
18
18
18
30
NTR
12
22
22
22
22
22
22

Figure 1

FIG 2A

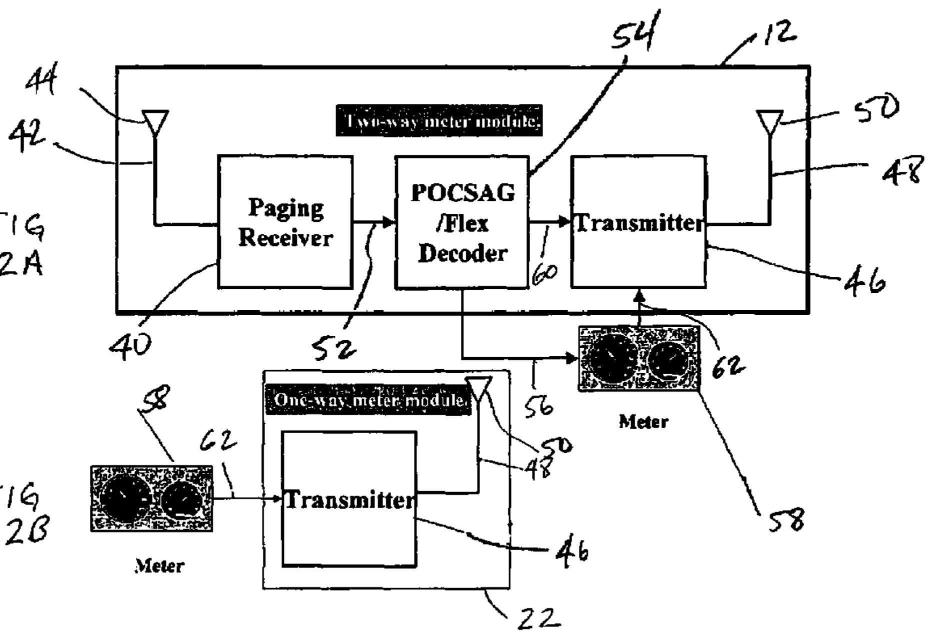

Two-way meter module
Paging Receiver
POCSAG /Flex Decoder
Transmitter
Meter
One-way meter module
Transmitter
Meter
44
42
40
52
54
12
50
48
46
60
56
62
58
22

FIG 2B

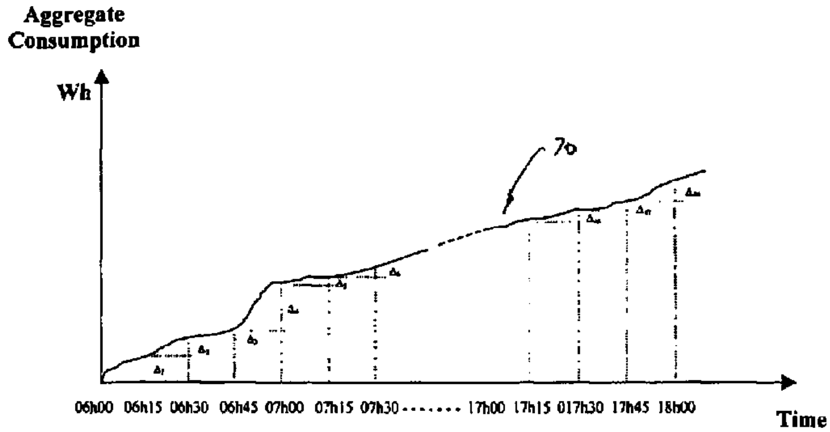
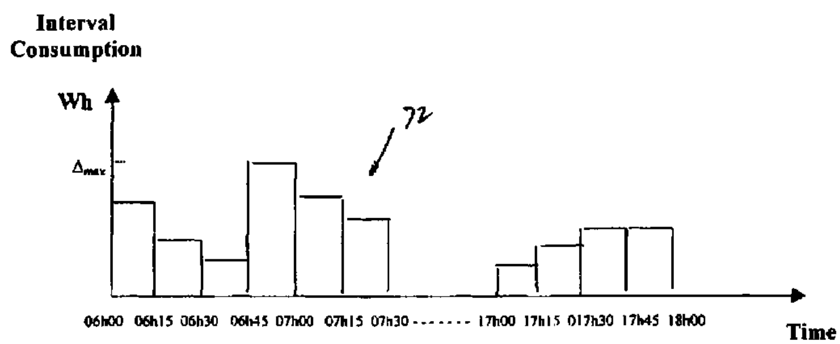


Figure 3A



6-10	600	300	200	800	600	500	200	100	0	0	0	100	100	200	0	0
10-14	0	0	0	0	0	0	0	0	0	0	900	1100	800	800	800	700
14-18	700	700	1000	900	300	400	0	100	100	600	800	1100	1600	1800	1000	1200

Figure 3B

Table 1:

Two-Bit Code	Wh Consumption
00	0
01	100
10	200
11	300

Table 2:

Two-Bit Code	Wh Consumption
00	0
01	100
10	300
11	600

Table 3:

Two-Bit Code	Wh Consumption
00	0
01	200
10	500
11	1000

Table 4:

Two-Bit Code	Wh Consumption
00	0
01	400
10	1000
11	1800

Figure 4

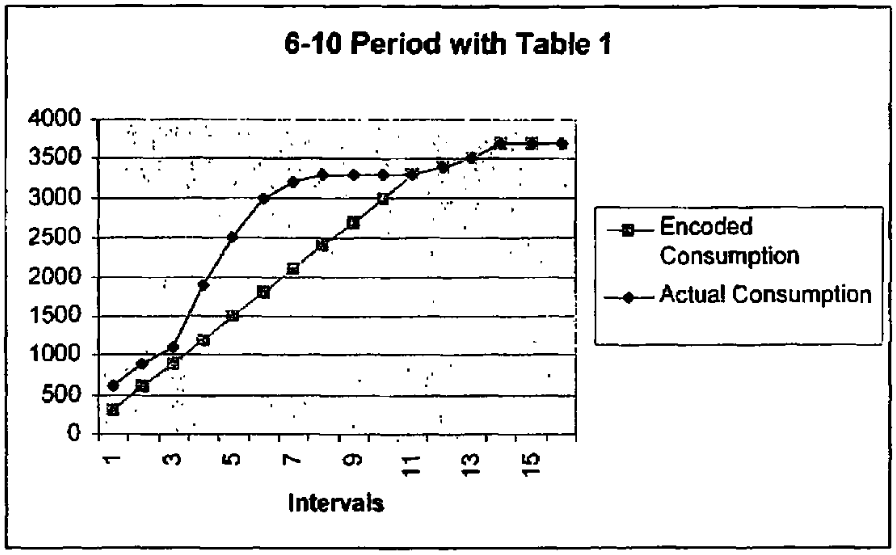


Figure 5A

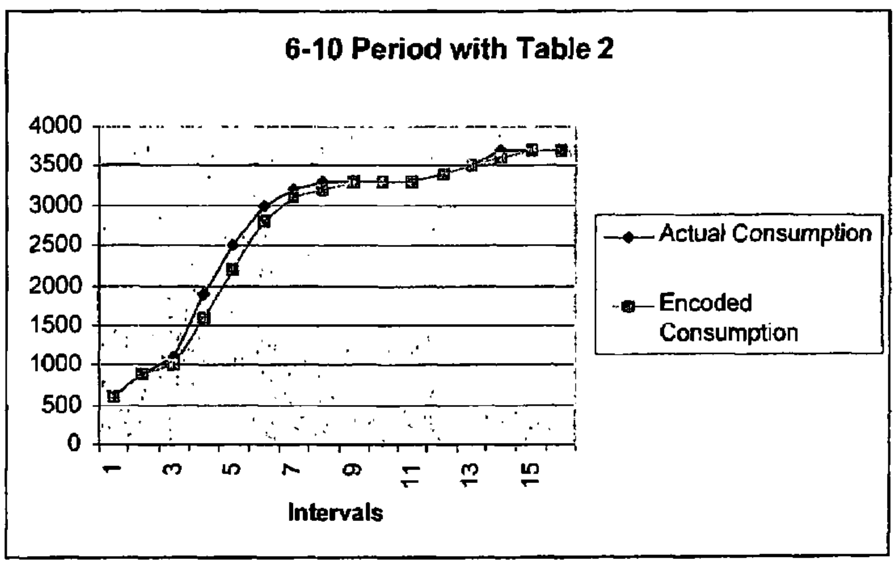


Figure 5B

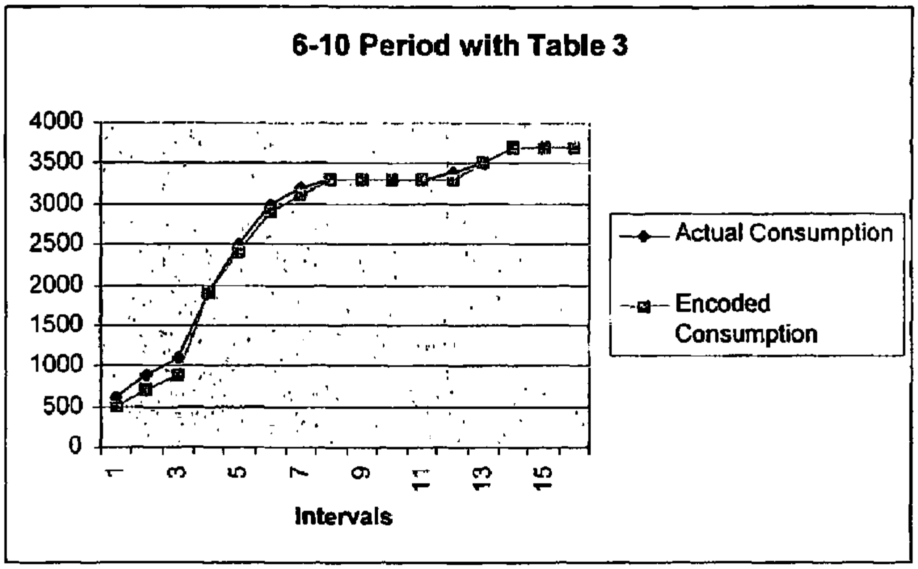


Figure 5C

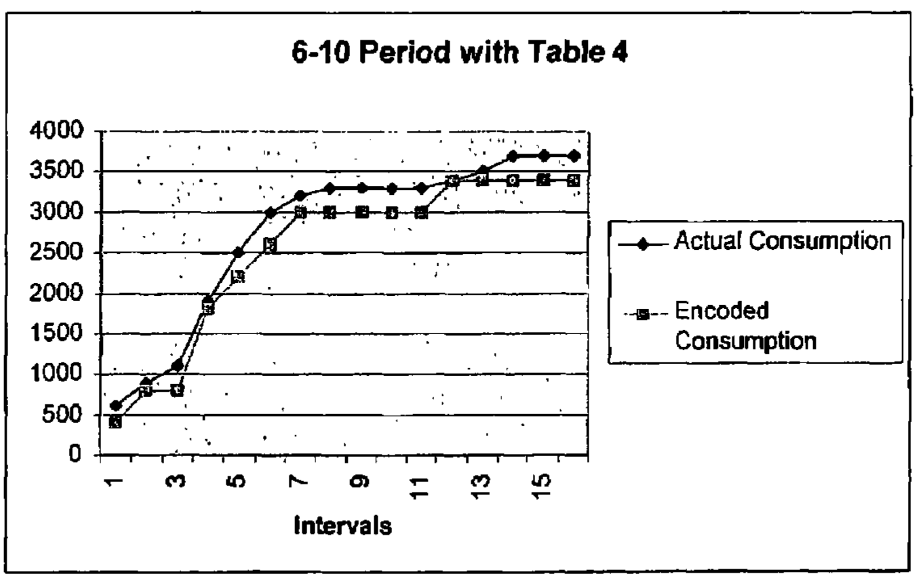


Figure 5D

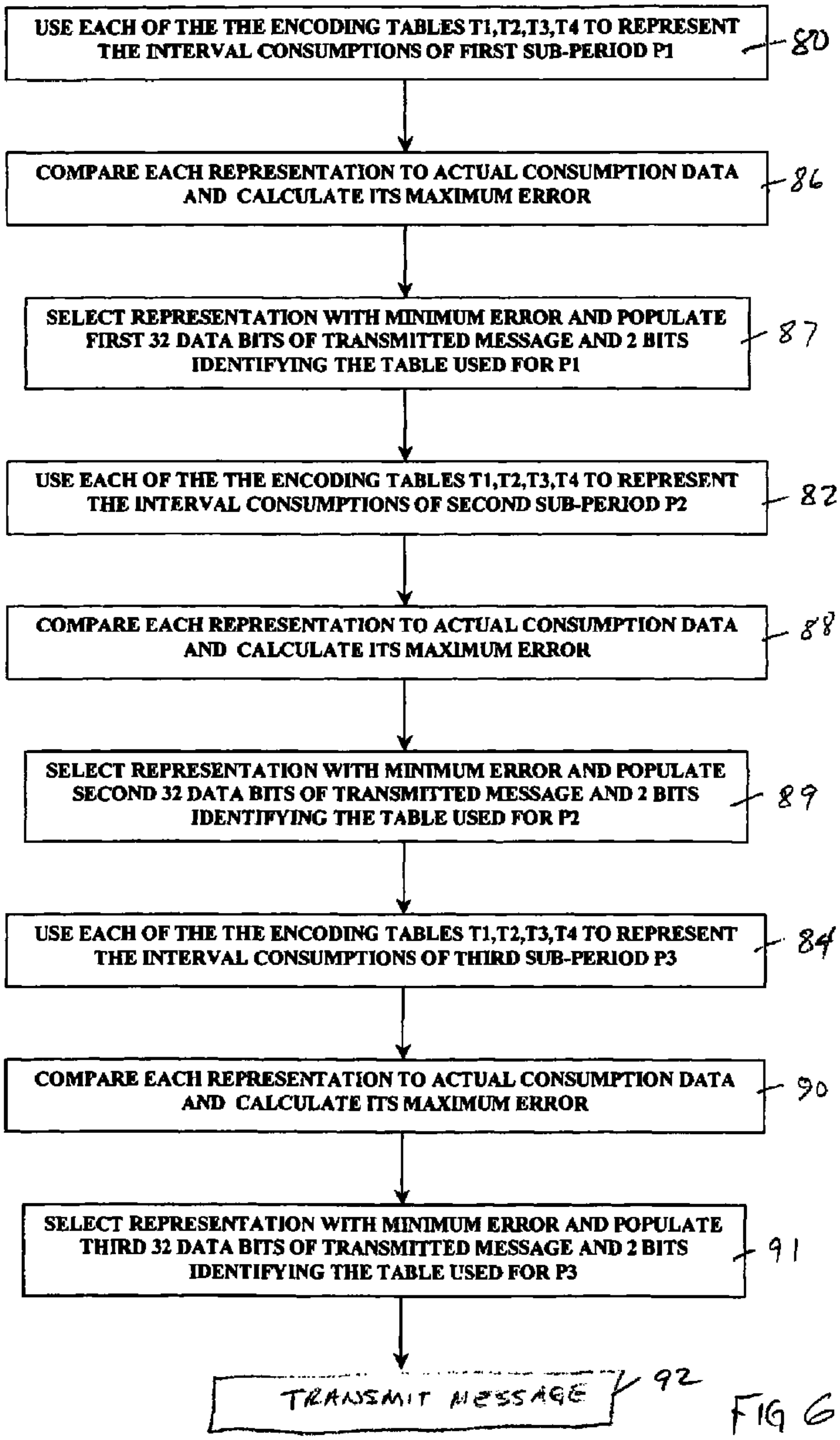

USE EACH OF THE THE ENCODING TABLES T1,T2,T3,T4 TO REPRESENT THE INTERVAL CONSUMPTIONS OF FIRST SUB-PERIOD P1
80
COMPARE EACH REPRESENTATION TO ACTUAL CONSUMPTION DATA AND CALCULATE ITS MAXIMUM ERROR
86
SELECT REPRESENTATION WITH MINIMUM ERROR AND POPULATE FIRST 32 DATA BITS OF TRANSMITTED MESSAGE AND 2 BITS IDENTIFYING THE TABLE USED FOR P1
87
USE EACH OF THE THE ENCODING TABLES T1,T2,T3,T4 TO REPRESENT THE INTERVAL CONSUMPTIONS OF SECOND SUB-PERIOD P2
82
COMPARE EACH REPRESENTATION TO ACTUAL CONSUMPTION DATA AND CALCULATE ITS MAXIMUM ERROR
88
SELECT REPRESENTATION WITH MINIMUM ERROR AND POPULATE SECOND 32 DATA BITS OF TRANSMITTED MESSAGE AND 2 BITS IDENTIFYING THE TABLE USED FOR P2
89
USE EACH OF THE THE ENCODING TABLES T1,T2,T3,T4 TO REPRESENT THE INTERVAL CONSUMPTIONS OF THIRD SUB-PERIOD P3
84
COMPARE EACH REPRESENTATION TO ACTUAL CONSUMPTION DATA AND CALCULATE ITS MAXIMUM ERROR
90
SELECT REPRESENTATION WITH MINIMUM ERROR AND POPULATE THIRD 32 DATA BITS OF TRANSMITTED MESSAGE AND 2 BITS IDENTIFYING THE TABLE USED FOR P3
91
TRANSMIT MESSAGE
92

FIG 6

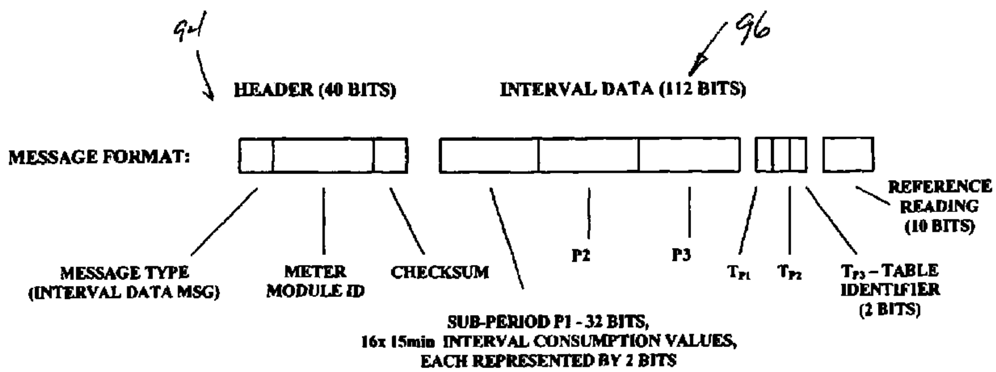

94
96
HEADER (40 BITS)
INTERVAL DATA (112 BITS)
MESSAGE FORMAT:
REFERENCE READING (10 BITS)
MESSAGE TYPE (INTERVAL DATA MSG)
METER MODULE ID
CHECKSUM
P2
P3
T_{P1}
T_{P2}
T_{P3} – TABLE IDENTIFIER (2 BITS)
SUB-PERIOD P1 - 32 BITS, 16x 15min INTERVAL CONSUMPTION VALUES, EACH REPRESENTED BY 2 BITS

FIG 7

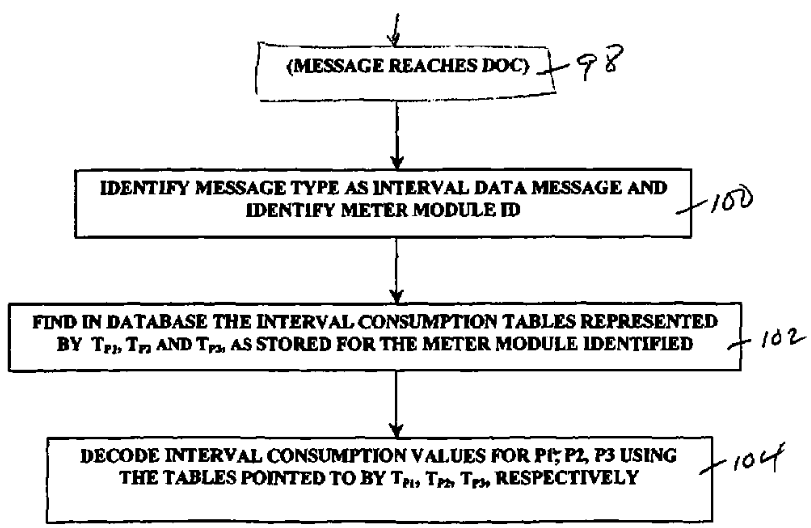
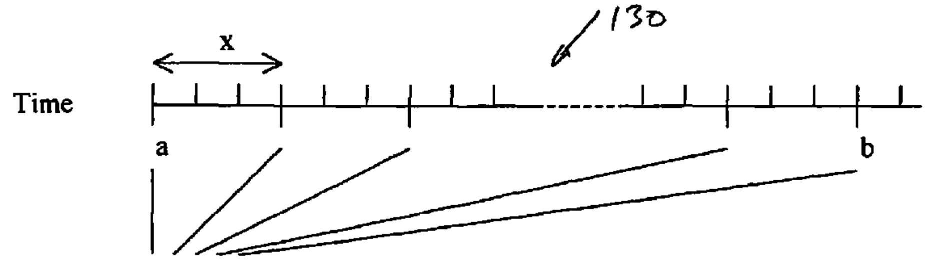
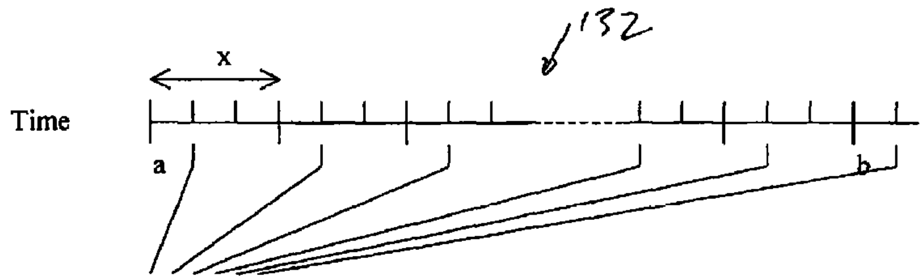

(MESSAGE REACHES DOC)
98
IDENTIFY MESSAGE TYPE AS INTERVAL DATA MESSAGE AND IDENTIFY METER MODULE ID
100
FIND IN DATABASE THE INTERVAL CONSUMPTION TABLES REPRESENTED BY T_{P1}, T_{P2} AND T_{P3}, AS STORED FOR THE METER MODULE IDENTIFIED
102
DECODE INTERVAL CONSUMPTION VALUES FOR P1, P2, P3 USING THE TABLES POINTED TO BY T_{P1}, T_{P2}, T_{P3}, RESPECTIVELY
104

FIG 8



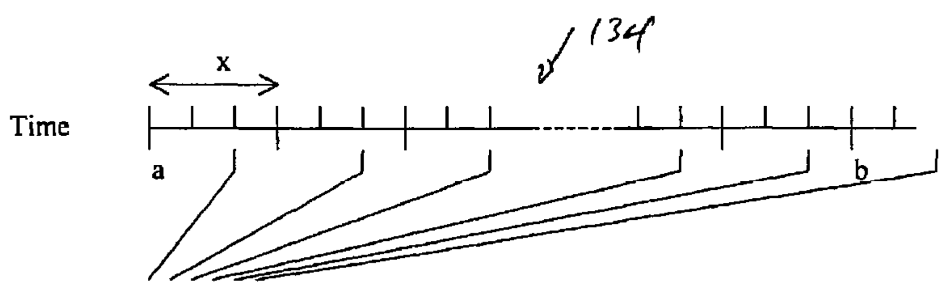
Sample times for Interval Consumption Data Air Message #1

Fig 9A



Sample times for Interval Consumption Data Air Message #2

Fig 9B



Sample times for Interval Consumption Data Air Message #3

Fig 9C

WITHOUT CONSUMPTION DATA INTERLEAVING:

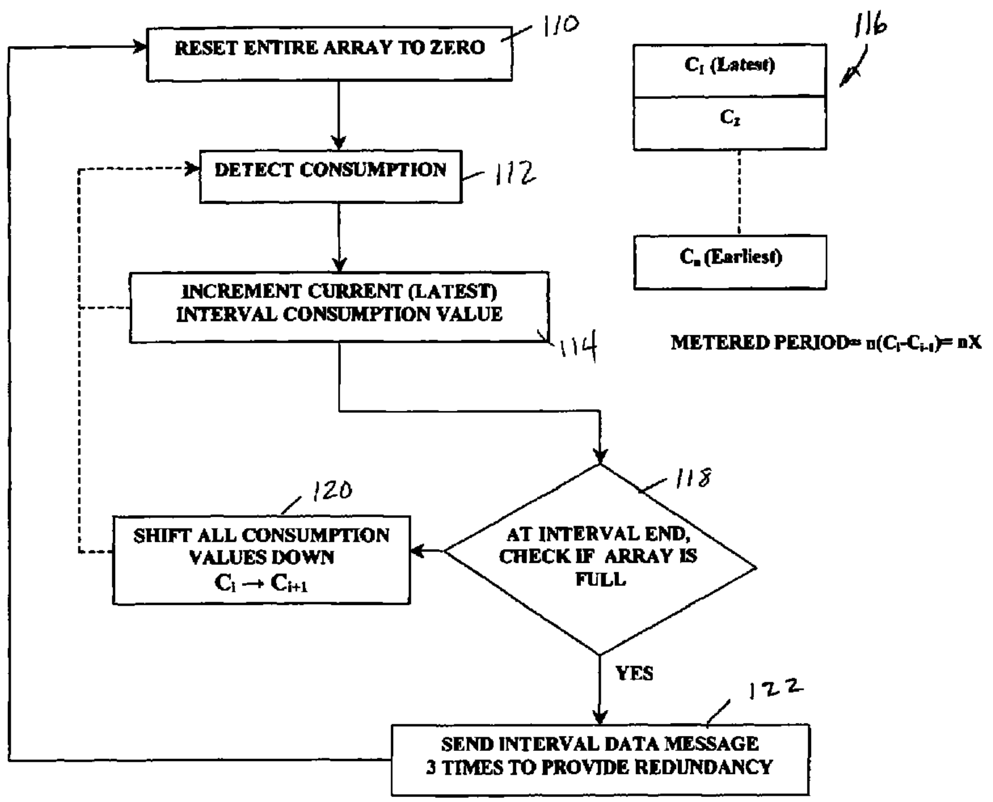


FIG 10

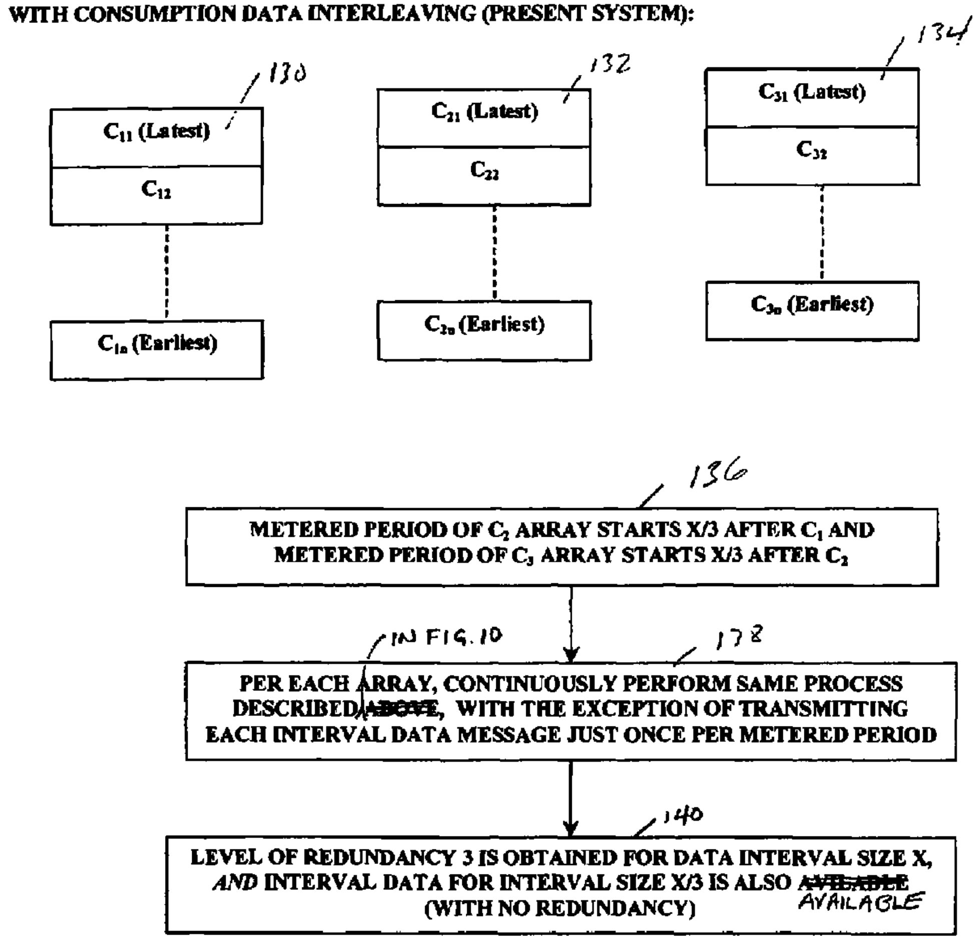

WITH CONSUMPTION DATA INTERLEAVING (PRESENT SYSTEM):
130
132
134
C_{11} (Latest)
C_{12}
C_{1n} (Earliest)
C_{21} (Latest)
C_{22}
C_{2n} (Earliest)
C_{31} (Latest)
C_{32}
C_{3n} (Earliest)
136
METERED PERIOD OF C_2 ARRAY STARTS X/3 AFTER C_1 AND METERED PERIOD OF C_3 ARRAY STARTS X/3 AFTER C_2
IN FIG. 10
138
PER EACH ARRAY, CONTINUOUSLY PERFORM SAME PROCESS DESCRIBED ~~ABOVE~~, WITH THE EXCEPTION OF TRANSMITTING EACH INTERVAL DATA MESSAGE JUST ONCE PER METERED PERIOD
140
LEVEL OF REDUNDANCY 3 IS OBTAINED FOR DATA INTERVAL SIZE X, AND INTERVAL DATA FOR INTERVAL SIZE X/3 IS ALSO ~~AVILABLE~~ AVAILABLE (WITH NO REDUNDANCY)

FIG 11

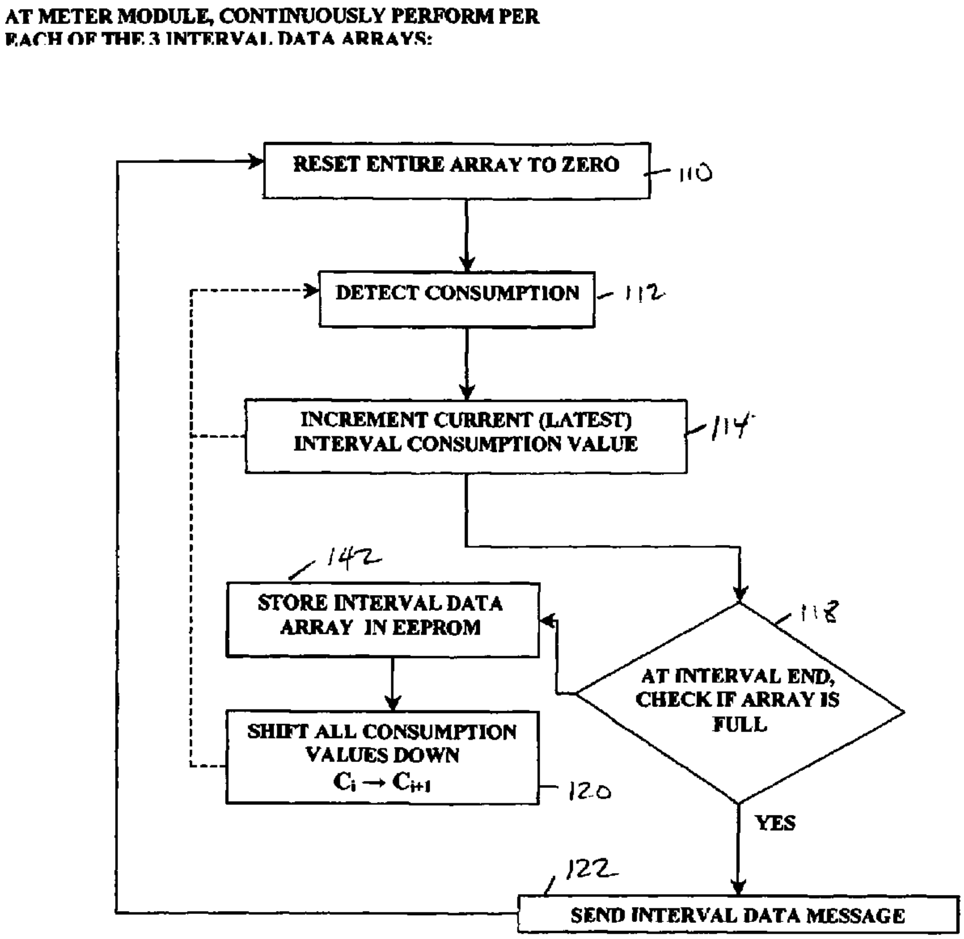

AT METER MODULE, CONTINUOUSLY PERFORM PER EACH OF THE 3 INTERVAL DATA ARRAYS:
RESET ENTIRE ARRAY TO ZERO
110
DETECT CONSUMPTION
112
INCREMENT CURRENT (LATEST) INTERVAL CONSUMPTION VALUE
114
142
STORE INTERVAL DATA ARRAY IN EEPROM
118
AT INTERVAL END, CHECK IF ARRAY IS FULL
SHIFT ALL CONSUMPTION VALUES DOWN
$C_i \rightarrow C_{i+1}$
120
YES
122
SEND INTERVAL DATA MESSAGE

Fig 12

WHEN OUTAGE IS DETECTED BY METER MODULE:

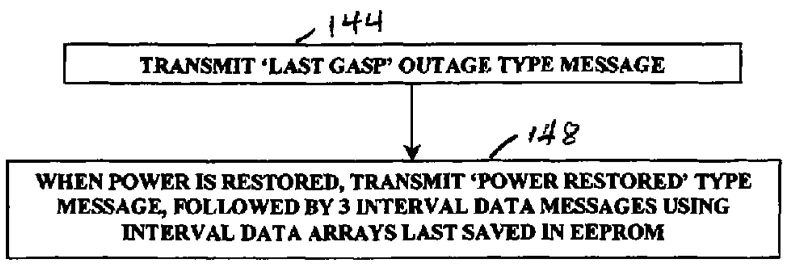


FIG 13

INTERVAL DATA RECONSTRUCTION AT DOC:

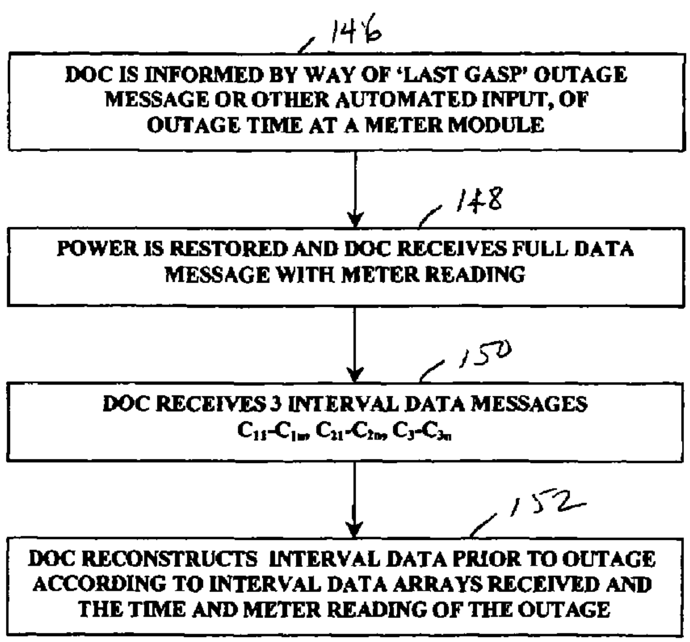


FIG 14

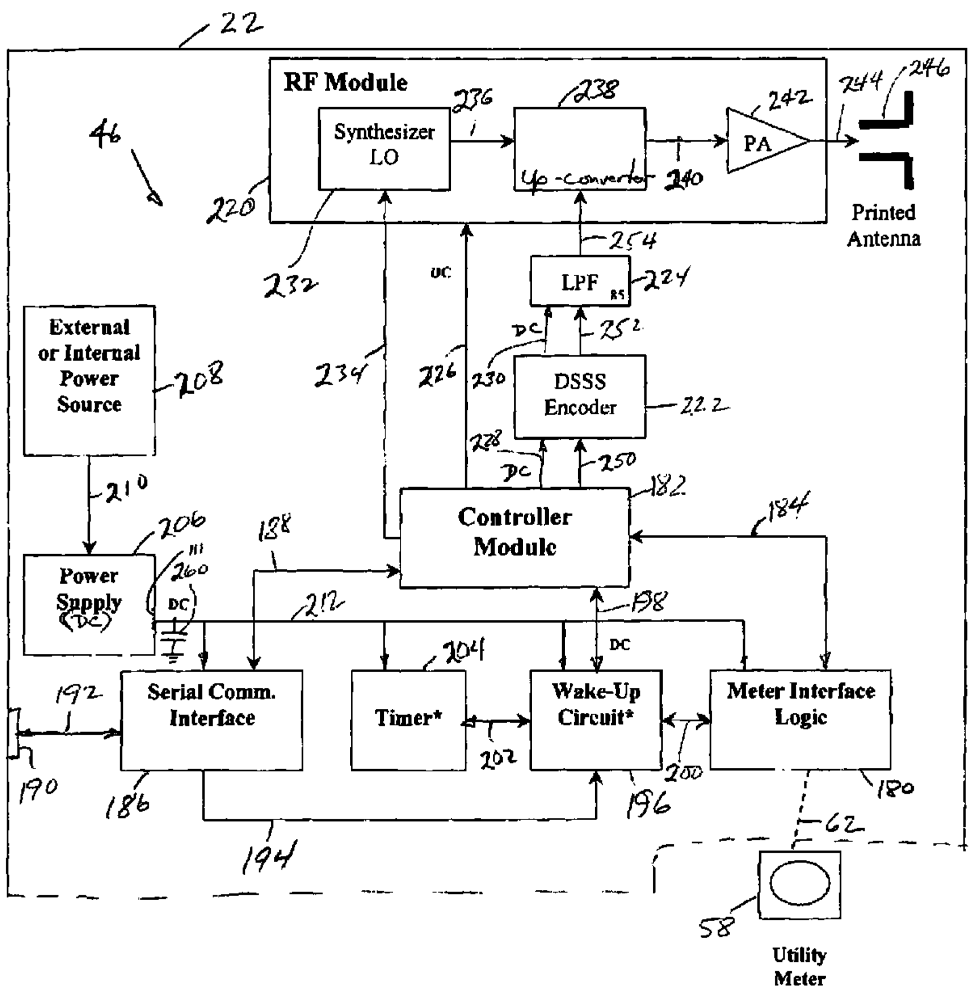

22
46
RF Module
Synthesizer LO
Up-converter
PA
Printed Antenna
LPF
DSSS Encoder
External or Internal Power Source
Power Supply (DC)
Controller Module
Serial Comm. Interface
Timer*
Wake-Up Circuit*
Meter Interface Logic
Utility Meter
DC
220
232
234
236
238
240
242
244
246
254
224
252
226
230
222
228
250
182
184
208
210
206
260
188
212
198
204
192
190
186
194
202
196
200
180
62
58

FIG 15

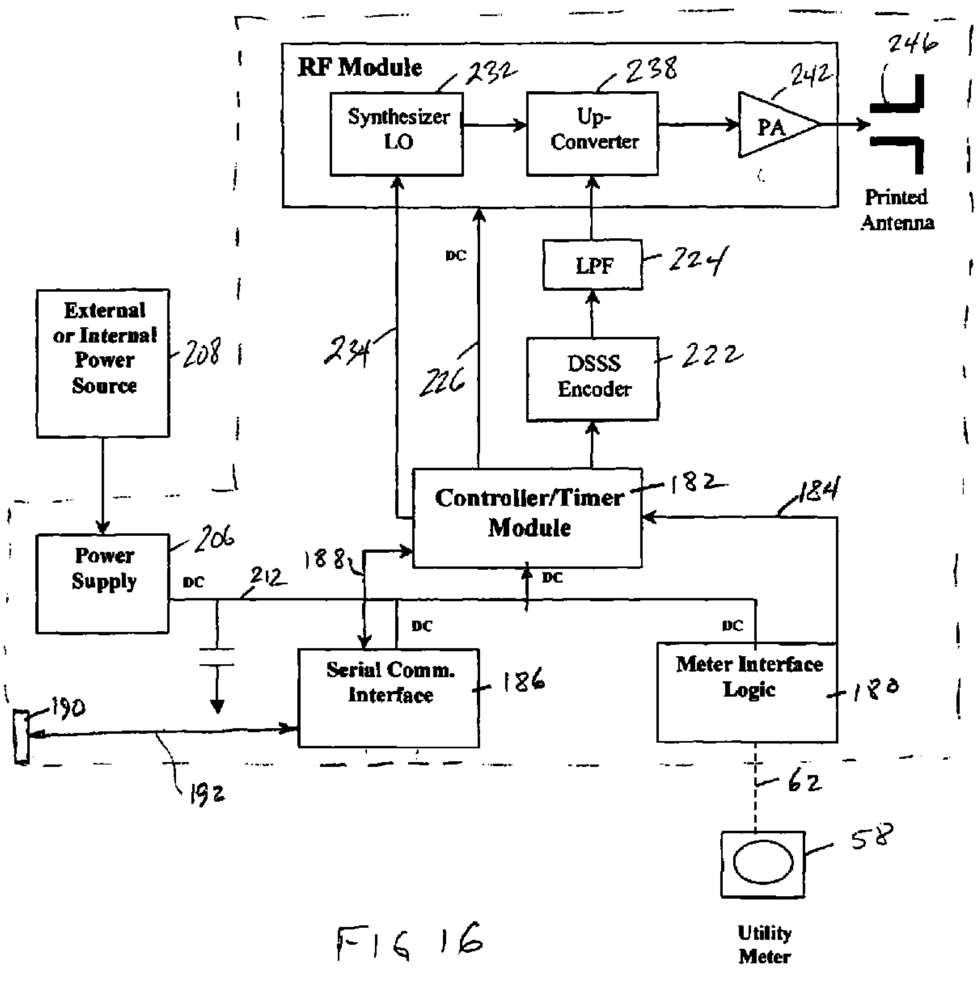

RF Module
Synthesizer LO
Up-Converter
PA
Printed Antenna
DC
LPF
DSSS Encoder
External or Internal Power Source
Controller/Timer Module
Power Supply
DC
Serial Comm. Interface
Meter Interface Logic
Utility Meter
232
238
242
246
224
222
208
234
226
182
184
206
212
188
186
180
190
192
62
58

FIG 16

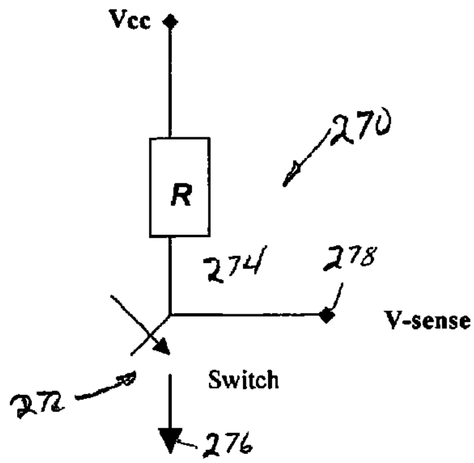


FIG 17
(PRIOR ART)

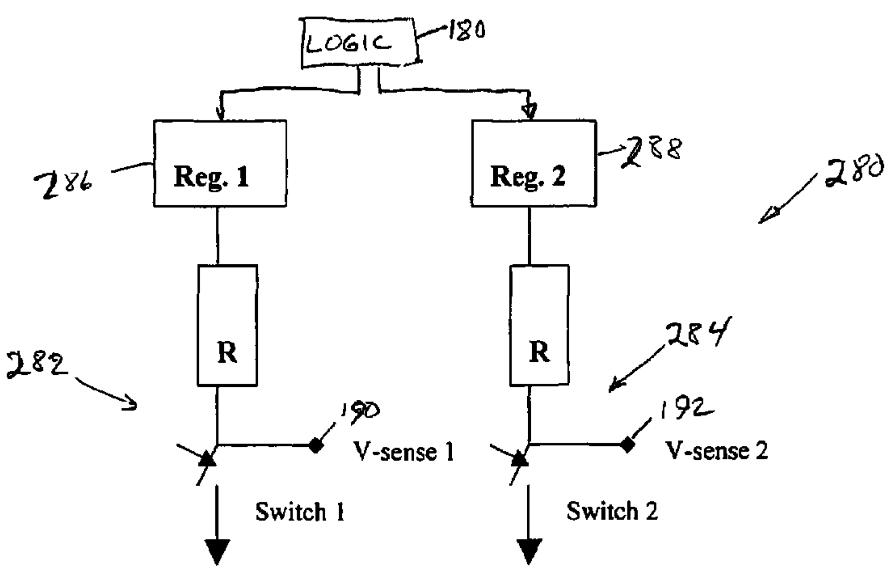


FIG 18

MODULAR WIRELESS FIXED NETWORK FOR WIDE-AREA METERING DATA COLLECTION AND METER MODULE APPARATUS

This application is a continuation-in-part of U.S. application Ser. No. 09/950,623, filed Sep. 13, 2001, the disclosure of which is hereby incorporated herein by reference.

FIELD OF THE INVENTION

The present invention generally relates to wireless messaging systems and methods. In particular, the present invention relates to wireless messaging systems and methods for automated meter reading (AMR) and metering data collection.

BACKGROUND

Automated Meter Reading (AMR) was developed as a more efficient and accurate method for utility meter data collection, as compared to prior manual meter reading of electric, gas and water meters, and several important advantages of AMR over manual meter reading helped develop it into a specialized branch of the data communications and telemetry industry. Worth noting among these advantages are the reliability, accuracy and regular availability of such metering data, which may be collected from hard-to-reach meter locations as well as from standard meter locations; higher customer security (no need to enter homes) and satisfaction (accurate bills); and reduced cost of customer service call center and service house calls for settling billing disputes.

Various technologies have been used in previous AMR systems to perform the tasks of interfacing the meter in order to sense consumption, communicating consumption data to a central site, and storing consumption data in a computer system at the central site. Wireless technologies, which have become the most common in AMR system implementation due to the ease of the installation process and, in many cases, the low initial and operating costs of the system, include both mobile data collection systems and fixed-base data collection systems, or networks. Although both provide a more reliable method of collecting monthly meter reads for billing purposes, fixed networks have some distinct, and important, advantages, brought about by the capability of such systems to provide frequent (typically at least daily) consumption data collection, which is difficult to do with typical mobile systems. Other advantages include: flexibility of billing date; marketing tools such as time-of-use (TOU) rates, demand analysis and load profiling, which enable clearer market segmentation and more accurate forecasts for utility resource generation, and also serve the goal of energy conservation and efficient consumption; and maintenance tools such as immediate notification of utility resource leakage or of account delinquency. These advantages have triggered increased interest and commercial activity regarding fixed network data collection systems for utilities, particularly utilities in regions undergoing deregulation of utility services.

Several methods and systems for implementing fixed-base data collection from a plurality of remote devices, such as utility meters, to a central location, have been developed and introduced in the past years. A categorization has evolved within the AMR industry, generally differentiating between one-way and two-way wireless data networks. Some systems require that each meter module on the network be a two-way module, i.e. contain a receiver circuit in the meter module. Although two-way communication features such as on-demand meter reading and other remote commands for meter configuration and control are generally desirable, they may not be required for the entire meter population of a utility. Since the inclusion of a receiver in the meter module contributes significant cost to the module, it would be most desirable to allow a utility service company the flexibility to deploy an AMR network which may contain and support both one-way and two-way meter modules.

One-way (collection only) data networks can support the large volume of data expected with the use of advanced metering applications, as by deploying intermediate data collection nodes, each of which creates a small data collection cell with a short-range RF link and a typical service population of several hundreds of meters. In such networks, the intermediate data collection nodes receive messages from meter modules, perform metering data analysis, and extract, or generate, specific meter function values to be transmitted to the next level in the network hierarchy. A wide-area network (WAN) may be provided to connect the intermediate level to the higher level. This configuration, which distributes the 'network intelligence' among many data collection nodes, serves the purpose of reducing the data flow into the central database when a large number of meters are analyzed for load profile or interval consumption data. It also serves the purpose of reducing air-message traffic between the intermediate node and the higher-level concentrator node. However, this configuration becomes inefficient in the common case where only a part, or even none, of the meter population requires advanced metering services like time-of-use (TOU) rates, while basic daily metering service is required for the whole meter population. This inefficiency is imposed by the short-range radio link between the meters and the data collection nodes, which significantly limits the number of meters a node can serve, regardless of how many meters need to be read frequently for interval consumption data. In this case, an expensive infrastructure of up to thousands of data collection nodes may be deployed, which often results in a great deal of unused excess capacity. A more efficient network would therefore be desirable, in order to reduce basic equipment cost, as well as to reduce installation and ongoing maintenance costs.

Another inefficiency arises due to the fact that with a large number of data collection nodes, the most cost-efficient wide area network (WAN) layer in these multi-tier networks would be a wireless WAN. However, to avoid interference from meter modules, as well as to avoid over-complication of the data protocols, an additional, licensed frequency channel is typically used for the WAN, adding to the overall cost of services to the network operator. A network composed of only one wireless data collection layer would therefore be desirable, particularly if operating in the unlicensed Industrial, Scientific and Medical (ISM) band.

Yet another disadvantage of networks with distributed intelligence among data collection nodes is the limited storage and processing power of these nodes. A system that could efficiently transfer all the raw data from the meter modules to the network's central database would therefore be desirable, since it would allow for more backup and archiving options and also for more complex function calculations on the raw meter data.

Another prior data collection network includes only a few reception sites, each one capable of handling up to tens of thousands of meters. In order to obtain long communication range, meter module antennas must be installed in a separate

(higher and/or out of building) location from the meter module, and wiring must be added between the meter module and the antenna, creating significant additional cost to the meter module installation, and significantly reducing the commercial feasibility for practical deployment of the network.

None of the above-mentioned systems of the prior art offers a level of flexibility that will enable a network operator to deploy a reliable, low cost, fixed data collection network, which will meet a wide range of AMR application requirements, from basic daily meter reads to full two-way capabilities. Inefficiencies exist in the prior two-way networks, in which the two-way capability is imposed on the entire meter population, and also in the prior one-way networks, in which small cell configuration requires a large, unnecessary investment in infrastructure.

It is therefore desirable to introduce a simple to deploy, but highly scalable, modular, and reliable data collection system, which would offer a wide range of service options, from basic metering, to advanced applications based on interval consumption data, to full two-way applications, while keeping the system's deployment and ongoing costs proportional to the service options and capacity requirements selected for various segments of the meter population.

SUMMARY OF THE INVENTION

According to a preferred embodiment of the present invention, a one-way direct sequence spread spectrum (DSSS) communications network, implementation of which is well-known in the art, is used as the data collection channel (uplink) of an automatic meter reading (AMR) application, and an optional paging network, or other suitable forward (downlink) network, may be used in a cost-effective manner. The invention provides a wide-area data collection network which is capable of supporting as many meters on as large a geographical area as required by the associated metering application.

The communications network may include one-way meter modules (transmitters) each communicatively coupled to a corresponding electric, gas or water utility meter, and may include two-way meter modules (transceivers) each coupled to such a corresponding utility meter. The meter modules are simple to install, and are typically installed inside electric meters, are integrated (as between meter and index) in gas meters, or are provided as external units adjacent to water meters. The meter modules monitor, store, encode and periodically transmit metering data via radio signals (air messages) in an appropriate RF channel, typically within the 902–928 MHz Industrial, Scientific and Medical (ISM) band, allocated by the Federal Communications Commission (FCC) for unlicensed operation.

Metering data air messages are collected by a network of receiver Base Stations (BS), decoded and forwarded to a central location, referred to as a Data Operations Center (DOC), via a communication backbone such as a frame relay network. The DOC communicates with all the base stations, monitors their operation and collects metering data messages from them. The DOC may also be communicatively coupled to a paging network, or other wireless network, for sending downlink commands to the two-way meter modules in the network. By using appropriate design parameters of a DSSS signal transmitted by a meter module, air messages can be received at a range of over 5 miles in urban areas, allowing sparse infrastructure deployment for a wide variety of metering data collection applications.

By applying long range DSSS to AMR applications, a new level of functional flexibility and network efficiency may be obtained. These goals are additionally achieved by a low-cost, energy efficient meter module which provides significant benefits to the system, primarily by contributing to the long range of the wireless link by implementing a direct sequence spread spectrum (DSSS) signal transmitter of high output power and high interference rejection, while consuming very low average power, thus enabling long life (many years) battery operation.

One of the primary advantages of the invention is that it permits use of a long wireless communication link, which provides wide-area coverage with a small number of sites (typically tens of thousands of meters in a five-mile radius per base station), thereby simplifying network deployment, reducing infrastructure initial and ongoing costs, and reducing the number of potential failure points in the network to increase reliability.

Another advantage of the invention is the provision of a modular network architecture, enabling flexibility in network planning in order to optimize cost and capacity in various regions covered by the network. A part of the network's modularity is that a forward (downlink) channel, such as a paging network, can be integrated with the data collection (uplink) channel, providing a convenient transition to supplying data services to both one-way and two-way meter modules.

Still another advantage is the scalability of the network, which enables gradual and cost-efficient increase of infrastructure deployment in order to meet a wide range of application and capacity requirements, including requirements relating to interval consumption data applications. Another advantage is the routing of all raw metering data to the DOC central database, where it can be easily processed, archived and accessed.

Briefly, the invention, in its preferred embodiments, is a scalable and modular fixed-base wireless network system for wide-area metering data collection, composed of at least one of each of a meter module, a receiver base station, and a data operations center. The system in its basic form includes one-way uplink meter modules, but may be scaled up in its air message handling capacity and in its application features by integrating two way meters responsive to a wireless data-forwarding (downlink) channel, thus providing the system operator with considerable flexibility in the choice of network capacity, features and system cost.

The network components of the system of the invention include one-way (transmit only) and two-way (transmit and receive) meter modules, which monitor, store, encode and periodically transmit metering data via radio signals (air messages). Also included are receiver base stations, which receive, decode, store and forward metering data to a central database and metering data gateway, referred to as the Data Operations Center (DOC). Base stations do not perform any meter data processing, but simply transfer decoded air messages to the DOC. The data operations center communicates with all of the network's base stations and receives decoded air messages from the base stations. The DOC processes, validates and stores metering data in a meter database that it maintains for the entire meter population operating in the network and has the capability to export or forward metering data to other systems via standard data protocols.

An optional wireless downlink channel, such as a paging network, may be utilized to provide two-way service to two-way meter modules that may be operating in the net-

work. This downlink channel enables time synchronization and other commands to be sent to two-way meter modules.

The system of the invention permits optimal adjustment of network control parameters such as the quantity of base stations, the number of reception frequency channels, and the meter module message bit rate, according to application requirements such as message delivery probability, metering data latency and meter module battery life. The system may also include Network Transceiver/Relay (NTR) devices, designed to enhance network coverage in areas of poor or no initial coverage. The NTR devices retransmit messages only from designated meter modules, identified either by module identification number or by an appropriate flag in the meter module air message.

In one embodiment, the system utilizes a logarithmic table encoding method for compressing interval consumption data air messages to reduce the number of bits required in a message for each consumption interval. In this method, the DOC maintains a large list (bank) of consumption encoding/decoding tables, adapted to various consumption patterns. The DOC further maintains a registry specifying which set of encoding/decoding tables is assigned to each meter module, with the sets of tables potentially differing from one meter module to another. Also available is an interleaving encoding method for interval consumption data air messages, to increase the redundancy level of the data and/or to provide data for smaller consumption intervals. In this method, the time base for each interval consumption data message is shifted, compared to the previous message, in a cyclic manner, so that interval consumption data may be reconstructed even if some of the messages are not received.

The invention provides a low-cost, high-output-power meter module, which may operate in the system described above. The module includes a sensor, data storage and processing, a direct sequence spread spectrum transmitter which may have an output of between 0.5 and 1.0 watt, and an antenna, all within the same physical enclosure.

The meter module preferably is equipped with a power supply in which a capacitive element and a limited current source are combined, in order to allow high output power during a short transmission burst, which may also be initiated immediately in the event of a power outage. The capacitive element and the limited current source impose a physical limitation on the charge time and thus the transmission duty cycle to reduce interference that can be caused by a malfunctioning meter module to an acceptable level that does not affect network functionality.

The meter module maintains low power consumption in its meter interface circuitry, and low overall power consumption, by using two sensors to detect rotation in the meter being monitored. These two sensors are openable and closeable switches, of which only one (or neither) may have a closed switch status at any given time, with the switches being operated by the operation of the meter, as by rotation of a disk, for example. Each switch is connected to a sensor circuit, and by disabling a sensor circuit as soon as a closed switch state is detected, while simultaneously enabling the other sensor circuit, near zero current is drawn by the sensors.

The meter module also includes an outage recovery system, which provides immediate notification of outage ('last gasp'), immediate notification of power restoration, and storage of interval consumption data prior to an outage event, thereby enabling a transmission of the last saved data shortly after power restoration.

BRIEF DESCRIPTION OF THE DRAWINGS

The foregoing, and additional objects, features and advantages of the present invention will be understood by those of skill in the art from the following detailed description of preferred embodiments thereof, taken with reference to the accompanying drawings, wherein:

FIG. **1** is a block diagram illustrating required and optional components of a data collection network system according to an embodiment of the present invention;

FIG. **2A** is a block diagram illustrating a two-way meter module in accordance with the present invention;

FIG. **2B** is a block diagram illustrating a one-way meter module in accordance with the present invention;

FIGS. **3A** and **3B** are graphic illustrations of consumption data required to be transmitted in an air message;

FIG. **4** illustrates in tabular form examples of encoded logarithmic consumption data;

FIGS. **5A–5D** graphically demonstrate the evaluation process by which a meter module determines which consumption data-encoding table to select;

FIG. **6** is a flowchart of the process of generating logarithmic encoded interval consumption data;

FIG. **7** illustrates the message contents;

FIG. **8** is a flowchart of the process of decoding the transmitted message;

FIGS. **9A**, **9B** and **9C** illustrate interleaving encoding, which is used to generate interval consumption data air messages;

FIG. **10** is a flowchart illustrating the process for generating consumption data messages without consumption data interleaving;

FIG. **11** is a flowchart illustrating the process of generating and handling interleaving encoded interval consumption data messages;

FIGS. **12**, **13** and **14** are flowcharts of consumption data recovery in the event of power outage;

FIG. **15** is a block diagram of a first embodiment of the meter module of the invention;

FIG. **16** is a block diagram of a second embodiment of the meter module of the invention;

FIG. **17** illustrates a prior art 'zero current' rotation sensor;

FIG. **18** illustrates a zero current rotation sensor in accordance with the present invention;

BRIEF DESCRIPTION OF THE PREFERRED EMBODIMENT

Data Collection Network

Turning now to a more detailed description of the invention, FIG. **1** illustrates a scalable and modular wireless fixed-base data collection system, or network **10**, comprising at least one wireless meter module, such as a two-way (transceiver) module **12**, at least one receiver site (base station) **14**, and one central site (data operations center) **16**, into which all metering data is collected. According to a preferred embodiment of the present invention, system **10** is an automatic meter reading (AMR) system which uses a one-way direct sequence spread spectrum (DSSS) communications network as a data collection channel (uplink) **18**. A downlink network **20**, which may be a paging system or other suitable downlink network, provides an optional forward (downlink) channel **21** in a cost-effective manner. The network **10** is designed to provide a cost-effective, wide-area data collection solution which is capable of supporting as

many meters in as large a geographical area as may be required by the associated metering application.

The communications system **10** may include one or more one-way meter modules (transmitters) **22** communicatively coupled, for example, to corresponding electric, gas or water utility meters, and may also include one or more two-way meter modules (transceivers), exemplified by module **12**, coupled to such utility meters. The meter modules **12** and **22** monitor, store, encode and periodically transmit metering data via radio signals (air messages), in an appropriate RF channel, such as the channel **18**. This RF channel is typically within the 902–928 MHz Industrial, Scientific and Medical (ISM) band, allocated by the Federal Communications Commission (FCC) for unlicensed operation. Metering data messages are collected by a network of receiver base stations **14**.

By using appropriate design parameters for a DSSS signal transmitted by meter modules **12** and **22**, air messages can be received at the remote base stations **14**. In a preferred embodiment, a signal of 1 Watt of output power, a raw data bit rate of 4000 bits per second, a high antenna efficiency (near 1) and a processing gain of 24 dB are used. In addition, appropriate error correction methods, as known in the art, are incorporated; for example, a convolution code with R value of ½ and K value of 5, combined with a data interleaving mechanism may be used. The reception range can then be estimated by using empiric models such as the Okumura model, which represents path losses in an urban environment, yielding an expected reception range of over 5 miles in urban areas, allowing sparse infrastructure deployment for a wide variety of metering data collection applications. The Data Operations Center (DOC) **16** communicates with all the Base Stations (BS), monitors their operation and collects metering data messages from them. The DOC **16** may be communicatively coupled to two-way modules in the network **10** by way of downlink network **20**, which preferably is a paging network, a cellular network, or other wireless network, for sending downlink commands to the two-way meter modules using suitable, wireless data protocols.

Since transceiver power consumption is greater than transmitter power consumption, it is generally preferable to use transmitters where the power source is limited. Gas and water meter modules generally have a limited power source, typically from a battery, so the meter modules attached to such meters are generally transmitters rather than transceivers. Electric meters can typically take their power from the electric grid, so their power is not limited, and hence transceivers are suitable for electric meters. However, because the cost of the transceiver meter module is greater than the cost of the transmitter meter module, electric meters may use a transmitter to save on the end unit cost. Thus, it is preferred that gas and water meters use transmitters only, while electric meters may use transmitters or transceivers according to the application requirements. The transceivers create a two-way system, which has the advantage of greater capacity than a one-way system, and which can provide additional services (such as remote connect or disconnect, over-the-air programming or reprogramming of meter module parameters, and others) that cannot be provided by a one-way system. The metering data collection system operates as a one-way data collection system if not coupled to a downlink channel. The basic one-way network may be scaled up to several higher levels of capacity and application features, as described herein, the highest level being reached by integrating a downlink channel in the system.

The system **10** thus comprises both one-way (transmitter) meter modules **22** and two-way (transceiver) meter modules **12** coupled to corresponding meters. All of the modules are able to transmit encoded DSSS radio signals representing metering data stored in the meter modules, such as current meter reading, tamper status, meter identification data and interval consumption data. A variety of utility meter module types (electric, gas, water) and models may operate in one metering data collection network, utilizing the module, hase station and data operations center infrastructure. Each receiver base station **14** is able to receive and decode DSSS encoded signals (air messages) generated by any of the meter modules **12** or **22**. The bandwidth of the DSSS signal is approximately 2 MHz, and the base stations are preferably optimized to receive signals in any radio frequency range between 800 MHz and 1 Ghz. In a preferred embodiment, the data collection network operates in the ISM band under the rules for unlicensed operation (Part 15 of the FCC Rules), and requires no licensing for any portion of its wireless uplink channel **18**.

According to the preferred embodiment, one or more base stations **14** are deployed to cover a geographic area. The number of base stations needed depends on the size and type of terrain within the geographic coverage area, as well as upon application requirements. A base station is typically installed at a high location (communication tower or roof top) and consists of at least one receiving antenna, RF cables and connectors, a DSSS receiver, and a communication interface such as a PPP router or CDPD modem. A base station may also contain a backup power source for continued operation during a specified period of outage. Base stations **14** receive metering data air messages from meter modules **12** and **22** on the uplink channel **18**, decode the radio signals, and relay the decoded metering data air messages to the DOC **16**. The DOC preferably is coupled to the base stations **14** via standard communication channels **24**, which typically may be using an IP network (such as frame relay or Internet). Other communication channels may be used between the DOC and the base stations, and such channels may be a wireless cellular network, CDPD, PSTN or a satellite data network.

The DOC **16** preferably includes, or has access to, a database **25** of all the meter modules **12** and **22** in the network **10**, and an Internet server enabling remote access to the database. This embodiment also may include email, fax, pager devices or voice message generators in the DOC **16** to provide alerts and event notification to the network users. The DOC **16** may be programmed to forward received data directly to a user or to export files to a buffer directory by using standard data protocols.

According to the preferred embodiment, the DOC **16** includes suitable programs for metering data validation, processing and storage, while the role of the base stations **14** is to decode air messages and forward raw metering data to the DOC for central processing. This network structure eliminates the need to monitor and control metering data processing tasks, which are carried out in multiple locations; instead, all metering data is stored in a central location, enabling fast data access response times. Further, the central location (DOC) is equipped with suitable backup storage means to provide a permanent record of all received data. Thus, two objectives are served: low initial and maintenance cost of base station hardware and software; and convenient, permanent access to all metering data collected by the network via one central data repository.

The basic architecture of the network includes transmitter meter modules **22**, base stations **14** and a DOC **16**. However,

the network is modular and may include a downlink network 20 and two-way meter modules 12, as well as message relaying devices 30 in the uplink (reverse) RF channel 18. In addition, as will be further described, the network 10 includes a variety of scalability mechanisms enabling cost-effective service in varying levels of network air-message traffic and various metering data applications.

According to a particular embodiment of the invention, a cost-efficient means for expanding network coverage is the addition of a Network Transceiver/Relay device (NTR) 30, for example in one or more of the channels 18 to provide coverage for meter modules experiencing poor or no base station coverage. This provides more flexibility to the network operator by creating another option for providing coverage to a limited geographic area. The cost of deployment and maintenance of an NTR is significantly lower than that of a base station so that, besides being a cost effective solution to poor coverage, it also may justify the enhancement of a network's coverage to areas of low population density, thus extending the reach of the automated metering data collection system. The deployment of NTR devices does not require the network operator to perform any changes in any of the other elements of the network infrastructure.

In the design of the system 10, an analysis of expected radio traffic may indicate sufficiently high radio traffic to cost-justify full base station coverage. However, in any network it is likely that there will be certain areas, or "holes", in which radio traffic will be very sparse and which cannot cost-justify Base Station coverage. NTRs may then be used to provide sufficient coverage at much lower cost. For example, a small number of meters might be located in a deep valley, and so might not be covered by the nearest base station, but the deployment of a new base station might not be economically justified. In this case, an NTR, which only needs to provide limited coverage and thus is smaller in size than a base station, may be mounted at a common site such as on a pole top, so that its ongoing site lease cost would be significantly lower than that which an additional base station would require. The use of a NTR is thus a low-cost means of covering holes in the coverage of the base station network, or of extending the network's coverage to areas of low air-message traffic.

The network transceiver/relay device 30 illustrated in FIG. 1 may receive metering data messages from one or more meter modules 12 and 22, and operates to decode and retransmit messages from specific meter modules. NTR devices 30 are used in specific terrains that endure poor radio coverage, as described above, or may be used to remedy other situations where there is a lack of coverage or where coverage degradation occurs. The NTR 30 preferably is a low cost data relay node, which includes a DSSS receiver that may have lower RF sensitivity and smaller coverage (hundreds of meters) than a base station, and that also includes a DSSS transmitter. Like the base station, the NTR does not perform any metering data analysis; it only receives, encodes and retransmits raw data air messages that are identified as coming from specified meter modules listed in the NTR's memory. The relayed messages may then be received by a nearby base station 14.

In another embodiment, the NTR 30 may include a program which checks for an NTR flag bit in a received air message that indicates whether or not to relay the message. If desired, this embodiment may be combined with the above-described embodiment in which the NTR 30 only receives air messages from listed meter modules to allow selection of specific meter modules which will have their air messages retransmitted, with each meter module being programmed to use its NTR flag in order to have only some of its air messages retransmitted. This enhances network coverage, without creating unnecessary air message traffic.

One embodiment of a two-way meter module, such as that indicated at 12 in FIG. 1, is illustrated in the block diagram of FIG. 2A. This module is capable of transmitting metering data air messages on demand; for example, upon receiving an appropriate downlink wireless command. Alternatively, or in addition, the module may also be conveniently programmed to transmit at specific times by incorporating and maintaining a real-time clock which may be synchronized, for example, by a suitable signal transmitted in the wireless downlink channel 21. Two-way meter modules preferably also receive, decode and execute other commands such as commands to program meter parameters, to display messages or alerts on the meter's display, and to disconnect and reconnect power to the utility meter's load.

As illustrated in FIG. 2A, the two-way module 12 incorporates a receiver 40 connected by way of inlet line 42 to an antenna 44, and a transmitter 46 connected by way of outlet line 48 to an antenna 50. The receiver 40 may be a pager receiver, for example, and includes an output line 52 connected to a POCSAG/Flex Decoder 54 which receives and decodes downlink wireless command signals for controlling the module. One decoder output line 56 leads to a meter 58, which may be a utility meter or the like as discussed above, to provide command signals to the meter, while a second decoder output line 60 leads to the transmitter 46 to control its operation; for example, to turn it on and off at selected times. The meter 58 is connected to the transmitter 46 by way of meter output line 62, to supply data which is to be transmitted.

FIG. 2B is a block diagram of a one-way meter module 22, which includes a transmitter such as the transmitter 46 of the module 12, connected to antenna 50 by way of line 48 and to meter 58 by way of line 62. The transmitter in this module is controlled by an internal clock to operate periodically to transmit data from the meter 58. The basic transmitter apparatus will be described below. A trade-off exists between the amount of data required by a particular use of the system and the maximum number of air message transmissions that can be accommodated while still maintaining air message traffic or meter module battery life at acceptable levels. In the preferred embodiment, the system is designed so that the network operator or deployment planner has the flexibility to optimize space diversity, frequency diversity and air message duration according to the various requirements of delivered metering data, meter module battery life, metering data latency, and air message delivery probability.

To meet these various requirements, five different levels of network capacity control may be provided by the system, depending upon customer demand, it being noted that levels 2 to 5 described below may be implemented in any order. The most basic system capacity may be defined as Level 1, wherein a sparse base station network is deployed, combined, if necessary, with NTR devices which would cover areas with very limited radio traffic. This level, which provides adequate geographic coverage and a minimum level of system capacity, is roughly defined as the network capacity required in order to provide daily readings of meters in an urban meter population. A typical urban deployment for this level would include base stations spaced 5 miles apart, each covering up to several tens of thousands of meters, with few to no deployments of NTR devices. As an example, a basic configuration may utilize one RF channel,

and provide daily coverage for 99% of an area, in which 50,000 meters are deployed and are transmitting daily, the area being covered by five Base Stations. Additional capacity requirements may be triggered by significant growth in the meter module installed base and/or by new applications requiring more data to be delivered daily from each meter module. In order to maintain a desired level of data collection services, one of the four measures described below may be used.

To obtain a higher, Level 2, system capacity, a space diversity technique is used. In this arrangement, the number of base stations is selected to provide coverage for a specified meter population and a specified metering data application in a specified geographical area. In the initial phase of planning, the system coverage for this level includes selection of the optimal number and locations of base stations to be deployed in the specified area. However, when a base station covers a large area and the meter module density or air message frequency requirements increase above the initial design coverage, at some stage the farthest meter modules encounter interference from the closer meter modules, and message reception probability from the farthest meter modules decreases. To overcome this problem, base stations may be added at appropriate locations in the same geographic area, thereby increasing network capacity and message reception rate. Adding base stations reduces the effective range between each deployed meter module and the base station closest to it, so that more meter modules, or potential meter module locations, are within a range of high air-message reception probability. Thus, the placement of additional base stations in the same geographic area, without any other change in the network or the meter modules, will in itself increase overall network capacity.

Another approach to increasing network capacity, defined as Level 3, utilizes frequency diversity, which is implemented by utilizing more than one frequency for uplink channels within a given coverage area. The uplink channels **18** would normally operate on the same radio frequency, but selected meter modules may be programmed to alter their transmission frequency channel; for example, to transmit each successive air message on a different frequency. To accommodate this, the corresponding base station would include several receivers each tuned to a different frequency, or a single receiver having multiple frequency channels, thus significantly increasing the base station's air message reception capacity. Frequency diversity may eliminate or at least postpone coverage problems, which would otherwise require adding base station sites. In addition, frequency diversity may be combined with space diversity by feeding receivers operating in different uplink frequency channels at the same base stations with signals from separate antennas. In the 902–928 MHz unlicensed ISM band, a particular embodiment of the network may operate in up to 57 channels, spaced 400 kHz apart, but a more practical limit for reliable operation would be about 10 channels. Each new frequency channel added to a receiver increases the base station's capacity, and when a regional base station network is being used, adding channels significantly increases the entire network's capacity.

Still another approach to increasing system capacity, defined as Level 4 and which may be included in the preferred embodiment of the system, consists of modifying the length of the direct sequence code used to encode the command and data signals in the network, although this forms a trade-off with the air message's raw data bit rate parameter. In one embodiment of the invention, for example, the direct sequence chip rate for the code may be 1 Mchips/sec with a maximum code length of 255 chips, yielding a data rate of about 4 kbps. To modify this, the network operator/planner may select shorter codes, namely 63, 31 or 15 chips long, thus increasing the raw data bit rate. Reducing code length reduces the signal spreading and decreases the coverage range per base station, but on the other hand increases each base station's air message capacity because of the shortened air messages.

The highest level of air-message capacity, which may be defined as Level 5, can be attained in a data collection network by utilizing a downlink channel and two-way transceivers rather than one-way transmitter meter modules. A two-way system has the inherent potential to be more efficient with radio air time resources, since field units may be synchronized to a central clock to allow transmission only in allocated time slots. The higher the number of two-way meter modules in a metered population, the higher is the network capacity increase provided by adding the downlink channel. A wireless data collection network in which the modules incorporate transceivers as described above may be scaled up from one-way (data collection only) to two-way, simply by connecting the DOC **16** to a wireless downlink channel **20**. The measures described in levels 2 to 4 above may be implemented in such a two-way network as well, in order to further increase network capacity.

Integrating a downlink channel such as channel **20** is a cost-efficient scaling-up procedure, which provides significant enhancement of both network air-message capacity and metering data application functionality. This enhancement does not require the network operator to perform any changes in any of the already existing elements of the network infrastructure, if the modules already contain transceivers.

In a preferred embodiment of a two-way metering data system **10**, both one-way (transmitter) and two-way (transceiver) meter modules are utilized. Transceivers can be interrogated for data at the time that the data is required, thus eliminating the need for the retransmitted transmissions which are required in a one-way network in order to maintain a certain level of data latency. In addition, by synchronizing all transceiver modules to one central real-time clock, a time slot for transmission may be allocated and specified for each transceiver in a coverage area, thereby increasing the efficiency of network air time usage. Although several advanced metering applications, such as demand and Time of Use (TOU) metering, are available from a one-way metering data collection network, two-way meter modules operating in the described two-way metering data network are capable of providing additional features, such as accurate interval consumption data measurement enabled by a regularly synchronized real-time clock, on-demand meter reading, remote disconnect and reconnect, remote programming of meter parameters, and remote notification of rate changes or other messages. The particular embodiment of the data system of the present invention enables the operator to mix on the same network, in a cost efficient manner, low cost transmitters, which provide a wide range of metering data collection features, and higher cost transceivers, which further enhance metering data application features, while maintaining the core advantages of sparse infrastructure and the low cost associated with unlicensed operation of the metering data collection branch of the network.

In addition to the scalability and flexibility provided by the levels of network architecture described above, another key feature of the system is application scalability, which is a cost-efficient method of enhancing the metering applications supported on the network. As described above, some

application features, including on-demand meter reading, remote disconnect and reconnect, remote programming of meter parameters and remote notification of rate changes or other messages, require that the network architecture be scaled up to a two-way network by adding a downlink channel. However, some applications based on interval consumption data, such as demand analysis, load profiling, and time of use rates, can operate successfully on a one-way network and, by using the method described hereinbelow, only a relatively minor increase in air message traffic occurs.

Consumption Data Encoding Methods

In the prior art, extensive infrastructure is deployed in order to collect interval consumption data frequently (e.g. every 15 minutes). However, in many cases, particularly in residential metering applications, consumption data may be required in high resolution, but some latency is permitted in data availability. For example, fifteen-minute demand analysis could be required, but may be performed each morning on data collected the previous night, allowing several hours in which to collect the required interval consumption data. It would, therefore, be beneficial for the network service provider to have the flexibility to deploy infrastructure appropriate to the application and invest in additional infrastructure for high-end applications, such as on-demand reads, only in proportion to the meter population for which it is required.

Such interval consumption data measurements may be obtained from a meter, in accordance with one embodiment of the invention. Such a measurement normally includes an array of interval consumption values, each one of the values representing the consumption increment of one interval. The meter module transmits a regular ('full data') message, that contains the exact absolute reading of the meter several times a day, and in addition transmits several messages daily ('interval data messages') that include the interval consumption data array and a reference reading (e.g. the least significant two digits of the meter reading). As a one-way system, the data collection network does not rely on a real time clock in the meter module, but rather uses a time stamp generated by the DOC. Therefore, the following method is used for generating interval consumption data at the DOC: when an interval data message is received, the DOC traces the most recently received full data message and 'completes' the most significant bits of the meter reading at the time of the interval data message. Then, using the increment values received in the interval data message, an absolute meter reading can be generated for all the intervals included in the interval data message. The result is an increasing function representing the meter reading at each interval, which is stored at the DOC.

In order to reduce the total length of air messages, or the total number of fixed-length interval data air messages transmitted by a meter module, a method referred to as "logarithmic table encoding" of consumption values is used, which encodes interval consumption data in the air message. This method maps the range of consumption values into a more limited number of values, for the purpose of reducing the number of bits of information transmitted over the air, with the mapping being executed by a series of tables, which are predefined according to the expected dynamic range of interval consumption values.

The charts **70** and **72** illustrated in FIGS. **3A** and **3B** are respective examples of aggregate and interval consumption versus time data that may be required by a demand analysis application. In this example, it is assumed that an accuracy of 0.1 kWh is sufficient. Also by way of example, consumption is measured over a 12 hour total time period during 15 minute intervals. In order to optimize a consumption profile, this total time period may be divided into several sub-periods; in this example, 3 periods of 4 hours each. A table showing numeric measured values for each interval is illustrated in FIG. **3B**. In prior meter reading systems, these values would be encoded for transmittal, and this would traditionally require an encoding table with values ranging from zero to 1800 Wh, in 100 Wh increments, i.e. 19 values, requiring 5 bits per each consumption interval to encode.

In the present invention, the overall air message traffic associated with interval consumption data applications is reduced by using, in this example, only 2 bits for interval consumption encoding. This encoding requires some approximation, which inevitably creates an error in the reconstruction of a consumption profile compared to the actual consumption, but by appropriate definition of a set of encoding tables for the meter module to use, an acceptable error level may be reached. Flexibility in assigning different encoding tables for different sub-periods also reduces the statistical errors in the decoded consumption profile.

The set of tables assigned to a meter module may differ from one meter module to another, according to the expected consumption patterns. The DOC maintains a bank of available tables from which a set of tables is defined for each meter module during installation. An example of such a set of encoding tables is shown in FIG. **4**.

The meter module selects an encoding table from its assigned set of tables by building a consumption profile with each of the tables stored in its memory, and comparing it to the actual profile (FIG. **3A**), stored in its memory as the aggregate of a series of actual interval reading values (FIG. **3B**). Then the meter module applies a criterion by which to select the best encoding table; e.g. the table that yields the lowest maximum error during the metered period, or the lowest variance between the encoded and actual profiles.

The encoded consumption profile is built in the following process: if during an interval, actual (aggregated) consumption reaches a value X, the interval consumption value which would bring the encoded consumption profile to the closest value less than or equal to X, and which is also represented by a two-bit code in the encoding table, is used in order to build the encoded consumption profile. Examples of constructed profiles vs actual consumption for Tables **1–4** of FIG. **4** are shown in FIGS. **5A–5D**, respectively. In the examples, if a minimum error criterion is applied for the 6–10 four-hour period shown, then Table **3** would be chosen for transmission, as it yields a maximum error of 200 Wh (0.2 kWh) during the period. A table is selected for transmission for the other two periods in the example of FIG. **3B** (**10–14**, **14–18**) in an identical process. A reverse process is applied at the DOC in order to extract the interval consumption data. Thus, the table set used by the meter module is retrieved and then the consumption profile is reconstructed for each sub-period.

A summary of the logarithmic encoding and decoding process is shown in FIG. **6**, where, for each sub-period **P1**, P2, P3, interval consumption values are calculated using each of the available four tables **T1**, **T2**, **T3**, **T4** as illustrated at blocks **80**, **82** and **84**. After each calculation, a criterion is applied for each period to select the most suitable table for encoding the interval consumption of that period, as illustrated at locks **86**, **87**, **88**, **89**; and **90**, **91**. Two bits that identify the table that was used for each period are also attached to the air message (total of 6 bits in the example), and the message is transmitted, at block **92**. The transmitted message is illustrated in FIG. **7** as including a message

header **94** which includes the identification (ID) of the meter module which has calculated the data, and then includes the data itself, as indicated at **96**.

As illustrated in block **98** of FIG. **8**, when the DOC receives the message from a meter module, it identifies the type of message and the ID of the transmitting module, as indicated at block **100**. The DOC then determines the tables to which the table identifiers in the message refer (block **102**), and once the tables are identified, the DOC decodes the interval data encoded in the message into actual consumption (Wh) values (block **104**).

As illustrated in FIG. **7**, an interval consumption air message in the provided example may contain 2-bit interval data for 48 intervals of 15 minutes; i.e. 96 bits, plus two bits identifying the table chosen for each of the three sub-periods, plus 10 bits as a reference meter read, plus a message header of 40 bits, for a total of 152 bits, compared to 5 bits×48 intervals, which would amount to 240 bits and a total of 290 bits including the header, in a traditional system with no logarithmic encloding. Thus, airtime usage or the number of required messages is reduced by about 47% using the described method.

In order to provide a high level of redundancy of interval consumption data, another data encoding method is provided, referred to as interval consumption data "interleaving air message encoding", which splits interval consumption values between separate messages. In a particular embodiment, depicted graphically in FIGS. **9A–9C**, and in FIG. **11**, three separate interval consumption data air messages **130**, **132** and **134**, are transmitted that relate to the same consumption period b-a. The first air message includes samples taken at times a, a+x, a+2x, . . . and is transmitted at time b. The second air message includes samples taken at times a+x/3, a+4x/3, a+7x/3, . . . b+x/3, and is transmitted at time b+x/3. The third air message includes samples taken at times a+2x/3, a+5×13, a+8x/3, b+2x/3, and is transmitted at time b+2x/3, as illustrated at block **136** in FIG. **11**. More generally, in order to spread transmissions during the day, the offset between interval data arrays may be x/3+Nx, where N is an integer.

In a prior art interval consumption data handling method, described in FIG. **10**, an interval consumption data array **116** is generated by filling the value C_1 with the incremental consumption of the current interval (block **114**), and shifting down all of the array cell values at the end of each interval X (block **120**). That way, after a metered period of nX, n values relating to the last n intervals are stored in the AMR module. Once the array is full it is ready for transmission (block **118** to block **122**). If, for example, a redundancy level of 3 is desired, it is obtained by sending each interval data message three times (block **122**). Then the array is set to zero (block **110**) and starts aggregating data for the next interval data message.

In a particular embodiment, described in FIG. **11**, the present system provides a redundancy level of 3, by storing three interval consumption arrays (**130**, **132** and **134**), while having their time base cyclically shifted by X/3 from each other (block **136**). Per each array, the meter module executes the same process described in FIG. **10** (block **138**), with the exception of needing to transmit the interval data message just once. The redundancy is provided by having three interval data arrays covering the same metered period, although not having the same interval start and end times within that metered period.

With interleaving encoding, internal consumption data is defined to have a resolution value corresponding to the size of the time interval between consecutive consumption values sampled. If a message is lost, interval consumption data is still available at the DOC with a resolution of x or better. If no messages are lost, the DOC can reconstruct the absolute reading in x/3 intervals. i.e. with a resolution of x/3, illustrated at block **140**. This way, the meter module maintains the potential to provide high resolution interval consumption data, but also provides lower resolution interval consumption data with a higher redundancy level than that available when data is not split as described above, as illustrated at blocks **138** and **140**.

Although each of the methods may be applied independently, by combining the two encoding methods described, a highly reliable and efficient interval consumption data collection system is provided. In the example of FIGS. **3A** and **3B**, **8** daily messages, which include two regular metering messages (not containing interval data) and six interval data messages (each one 152 bits long, as in the example above) are required to deliver interval data, with a redundancy level of 3, whereas without using the provided methods, and using a comparable message size of 150 bits, two regular metering messages and twelve interval data messages, or a total of 14 daily messages, would be required to achieve the same redundancy level. Therefore, the encoding methods provided by the present invention maintain high channel reliability while increasing network capacity, by 75% in this example.

The system of the present invention supports interval consumption data applications even when a power outage occurs. This is performed by appropriate utilization of the meter module non-volatile memory, and without requiring any backup battery. A method, combined with the methods described above for data encoding, for retrieving interval consumption data in a one-way data collection network after an outage event has occurred utilizes a meter module which periodically and frequently executes a procedure to update and store interval consumption data messages,—as illustrated in FIG. **12**. The purpose of this process is to prevent loss of interval consumption data upon the occurrence of an outage event. The flowchart of the data recovery process related to an outage shown in FIG. **12** is similar to that of FIG. **9**, but further includes storing consumption data in an EEPROM **142**. If an outage occurs, the meter module uses its power supply (referred to below in the meter module description) to generate a 'last gasp' message (block **144**, FIG. **13**) that indicates to the DOC (block **146** in FIG. **14**) that power is out for this meter module. Upon power restoration after outage (block **148**), the meter module's microcontroller "wakes up", and transmits a full data message which includes usual identification information, the reading from the EEPROM and also includes a flag signifying that power has just been restored as illustrated at block **146**. At the same time, a new interval consumption data cycle (period) begins, and shortly thereafter the last saved three interval data message (arrays C_{11}–C_{1n}, C_{21}–C_{2n}, C_{31}–C_{3n}) are sent.

As illustrated in FIG. **14**, block **150**, after the DOC identifies the power restoration message flag, it receives the interval consumption messages that follow it as the last saved interval consumption messages, enabling the DOC to reconstruct interval consumption data (block **152**) prior to the outage event. In addition, the next scheduled full data message, which follows the power restoration message is also flagged by the meter module as the 'second full data message since power restored'. This acts as a redundant measure to identify the last saved interval consumption message before the outage event. In order to provide interval data recovery after outage even in case the 'last gasp'

message was not received, the time of outage can also be input to the DOC from other systems (such as a utility customer information system).

Meter Module

The meter module apparatus used in the present system has unique features of low overall power consumption, high output power and low cost overall design, enabling long battery life and long communication range in a commercially feasible fixed wireless network for a variety of metering applications. Each meter module in the network continuously monitors the resource consumption according to an input sensor that is coupled to the utility meter. In a particular embodiment, the meter module may be integrated inside, or as a part of, the meter enclosure, but in any case the meter module stores and transmits a wide array of data fields related to the meter, including consumption data, meter identification and calculation factor data, and various status alerts. The meter readings are stored as an aggregated value and not as incremental values, thus maintaining the integrity of the meter reading if an air message is not received at the DOC.

A one-way meter module **22** (FIG. **2B**) transmits a metering data air message once every preprogrammed time interval, and a block diagram of a first embodiment of the module is depicted in FIG. **15**. In this particular implementation, the module includes a meter interface logic module **180** that collects consumption, tamper status and other data from an associated utility meter **58**. It should be noted that although FIG. **15** depicts a single meter interface module **180** for purposes of simplification, multiple meter interface logic modules may be used in a single transmitter to interface with corresponding utility meters. The meter interface logic module **180** operates continuously and draws only a small amount of current. It includes several standard sensors (not shown), such as magnetic reed switches or optical sensors to track consumption, tilt sensors for tamper detection, and voltage sensors to determine outage or power restoration events.

The module **22** also includes a controller module **182**, which typically is a microprocessor, connected to the interface logic module **180** by way of connector **184** and connected to a serial data communication interface **186** by way of conductor **188**. The interface **186** includes a short-range wireless magnetic loop output or other conventional personal computer data port (not shown) connectable by way of input port **190** and conductor **192** for testing and initialization of the transmitter at the shop or in the field. The interface **186** is also connected by way of conductor **194** to a wake-up circuit **196** which, in turn, is connected by way of connector **198** to the controller **182**, by way of conductor **200** to the meter interface logic module **180**, and by way of conductor **202** to a timer circuit **204**.

A DC power supply **206** is connected to an internal (battery) or external power source **208** by way of conductor **210**, with the DC power supply **211** output being connected by way of conductor **212** to corresponding inputs for interface **186**, timer **204**, wake-up circuit **196**, and meter interface **180**. The wake-up circuit **196**, when activated, connects the DC power on line **112** to conductor **198**, to thereby supply power to controller module **182**.

In the illustrated embodiment, the controller module **182** uses the auxiliary wake-up circuit **196** to manage a minimal power consumption level during the times in which the meter module is inactive ("sleep mode"). Upon receipt of a command from the controller **182**, the wake-up circuit **196** operates an electronic switch to disconnect the power supply from the controller itself, thereby also disconnecting the RF transmitter module to be described, thus allowing very low overall power consumption of the meter module during a "sleep" period. The wake-up circuit connects power back to the controller when triggered by an output from the meter **58** by way of interface **180**, by an external device by way of the port **190** and interface **186**, or by the timer **204**. This capability of the meter module is a particular value in battery-operated transmitters. However, it will be understood that if there is an unlimited power source, as may be the case if utility meter **58** is an electric meter, the controller **182** may operate continuously, in which case the wake-up circuit **196** would not be needed, as illustrated in FIG. **16**. In this second embodiment of an electric meter module illustrated in FIG. **16**, the timer **204** is a part of the controller module **182**, and the DC power conductor **212** is connected directly to the controller module **182**, instead of being connected through the wake-up circuit.

The meter module **22** also includes a radio frequency (RF) module **220**, a DSSS encoder **222**, and a low pass filter (LPF) **224**, connected to the power supply output conductor **212** by way of the controller module **182** and respective conductors **226**, **228** and **230**. The RF module **220** includes a synthesizer-controlled local oscillator (LO) **232** which is controlled by the controller module **182** by way of conductor **234** to provide a carrier output signal on line **236** to an up-converter **238**. The carrier signal is modulated in converter **238**, and the modulated output is supplied by way of output conductor **240** to a power amplifier (PA) **242**, the output of which is fed by way of output conductor **244** to an antenna **246**.

When the controller **182** determines that an air message is to be transmitted, it prepares a data packet, as described above, which is sent to encoder **222** by way of conductor **250**, where it is converted to a direct sequence through PN code generation and signal spreading. The spread signal is supplied by way of line **252** to the low pass filter (LPF) **224** where it is filtered and sent by way of line **254** to up-converter **238** where it is used as the modulating base-band signal for the signal to be transmitted. The power amplifier **242** produces up to 1 W of power for output to antenna **246**, which preferably is an on-board printed antenna. In the embodiment which utilizes the wake-up circuit **196**, once the controller **182** has handled the event that woke it up from its power-down mode, whether an air message transmission or other task was performed, it returns to its power-down (idle) mode.

In a preferred embodiment of the meter module of the invention, the power supply **206** is limited in order to maintain an acceptable level of radio interference in the event of uncontrolled transmission by a malfunctioning meter module, for one source of danger in the system is the possibility that a transmitter will malfunction and begin transmitting continuously. The result may be that the entire frequency channel would be blocked in that coverage area during the time of transmission, until the transmitter's power source dies. If the power source is a battery, this would be a relatively short period, but the interference would continue indefinitely if the power source is unlimited, such as would be the case if the meter is connected to an electric grid. Although this event is highly unlikely, in the meter module **22** described herein, a cost effective mechanism has been introduced to prevent uncontrolled transmission. This mechanism provides two additional benefits to the system: high output power with a limited power source and an immediate outage notification feature, also known as a 'last gasp' transmission.

The meter module's power supply **206** includes two specific physical limits to prevent continuous uncontrolled transmission; namely, a capacitive element **260** connected between output conductor **212** and ground, and a limited current source. The capacitive element **260**, which is used as a buffer stage between the energy source **206** and the load connected to output line **212**, stores sufficient energy to provide a high-power air message transmission, but due to its inherent physical limitations, the capacitive element can deliver sufficient power for transmission for only a limited period of time. Since the duration of transmission is relative to the capacitance of element **260**, and capacitance is related to the size of the element, the size of the capacitive element **260** is selected to be big enough to deliver enough energy for a complete transmission session, but not more than that. This way, the maximum potential blockage duration due to unwanted transmission is restricted to one transmission session. In addition, the limited current source in power supply **206** imposes a physical limitation on the recharge time required for the capacitive element to reach the required energy level for another air message transmission, thus limiting the on-off transmission duty cycle to a level that is harmless in terms of network capacity.

In a particular embodiment of the invention, the transmitted power is one watt, for a duration of 150 msec, and the power supply provides a recharge time of 90 seconds. This translates into a maximum of 960 messages per day, or 144 seconds a day, which is about 0.16% of the available time. Since network coverage is designed with a much higher safety margin, a malfunctioning transmitter would not be destructive to the network operation, allowing sufficient time for detection and identification of the source of the problem.

The described power supply enables the transmitter to generate high-power air message transmissions, even with a power source having a very low current drain. It also enhances electric metering applications by enabling a 'last gasp' metering data air message transmission when an outage event is detected by an electric meter module, if the capacitive element is fully charged.

As an illustrative example of the design and power supply we assume the following:

1. The transmission duration is 150 mSec.
2. The out put power is 1 Watt.
3. The power amplifier efficiency is 40% and its operation voltage is 5 Volts.
4. Minimum time between transmissions—90 seconds.

The energy required for a single transmission is 1 Watt×0.15 Sec/0.4=0.375 J. The energy stored in a capacitor is equal to E=0.5xCx(Vi^2−Vf^2) when C is the capacitor capacitance, Vi is the initial voltage of the capacitor and Vf is the voltage which remains in the capacitor after the completion of the transmission. Since the power amplifier requires 5V regulated voltage, a reasonable voltage for Vf is 8V. Selecting the capacitor's capacitance C and Vi can be done in more than one way, so additional considerations can be made, such as the availability of the selected capacitor in the market, its price, its size etc. If, for example, the capacitance is selected to be 2200 uF, then in this case Vi is equal to 20V. Since the device that converts the energy stored in the capacitor to a constant regulated 5V voltage to feed the power amplifier (typically a step down regulator) has less than 100% efficiency (typically 90%), Vi may be adjusted, taking into account the efficiency of the regulating device. A simplified charger can be implemented as a simple current source. Since the minimum time between transmissions is 90 seconds, the current source should be able to charge the capacitor from 8V to 20V in 90 seconds. Since I=CxdV/dT, we get I=2200 uF×12/90 =0.3 mA.

Conventionally, a utility meter such as meter **58** includes a rotating sensor which responds to the utility being monitored; for example, an electrical meter typically incorporates a rotating disk which responds to utility usage to drive the meter indicators. The rotation of such a disk can be monitored by a suitable sensor such as a magnet or a light sensor, for remote detection. Preferably, appropriate sensor circuitry and logic for this purpose is used in the meter interface logic **180** to enable the meter to be read with nearly zero power consumption, particularly in cases where the meter module **22** is powered by a limited power source, such as a battery.

A typical prior art sensor configuration is illustrated at **270** in FIG. **17**, and includes a switch **272** which is located in a meter **58** and has two operation states, open (illustrated) and closed. The switch is positioned to be activated periodically by a pin, or register, mounted on a rotating disk in the meter, in known manner. When the switch is open the circuit from voltage source Vcc through conductor **274** to ground point **276** is broken and the voltage measured at the V-sense node **278** equals the supply voltage Vcc. When the switch **272** is closed, the voltage measured at the V-sense node is the circuit's ground level reference voltage; i.e. zero voltage. Measuring the two electrical states at the V-sense node **278** allows the two switch states open and closed to be distinguished, with the periodic opening and closing in response to rotation of the disk providing a measure of utility usage.

Although most switches have finite conductivity, it is very low, and the typical power consumption when switch **272** is in the open state is acceptable for long operating life. However, during the closed state, power is consumed at a level that may be significant when the energy source is limited, as with battery-powered devices, and when that limited source must remain operative for lengthy periods of time, as is often the case with meter modules. In addition, the amount of energy wasted in this way typically cannot be predicted, and may vary widely with utility customer consumption patterns.

A preferred alternative to the sensor configuration of FIG. **17** may be referred to as a "Zero Current Sensor Configuration", and is illustrated at **280** in FIG. **18**. This implementation is based upon a component selection and geometrical arrangement of two sensor switches located in meter **58**, in which only one of the two switches may be triggered to a closed switch state for any possible position of a sensed rotating element.

In meter configuration **280**, two switches **282** and **284** are connected in series with respective registers **286** and **288**. These registers are activated or deactivated by control commands from the controller module **182** (FIG. **15**) by way of logic interface **180** and connector **62**. Loading a high state voltage from interface **180** into a meter register causes activation of the associated switch **282** or **284**, respectively. Loading a low state voltage into a meter register causes deactivation of the associated switch **282** or **284**. When a switch is deactivated by its register, no current can flow through the switch, even when the switch is closed. When no current flows, no energy is wasted, and this occurs when the switch is open, or when the switch is de-activated by its register, without regard to whether it is open or closed.

The controller module **182** is programmed to deactivate one of the two sensors through logic **180** by deactivating a sensor register as soon as a closed switch state is detected in that sensor. In addition, the controller module immediately activates the other sensor through its register. For example, if switch **282** is open and register **286** initially has a high

voltage state, then switch **282** is activated, but open. When this switch detects a predetermined condition, such as a projection element (magnet/reflector/pin) on a meter rotor, it changes its state from open to closed, and the voltage at node **190** (V-sense 1) is changed from the high state voltage of register **286** to zero. This voltage drop is detected by interface **180** which wakes up the controller module **182**. The controller then deactivates switch **282** by loading a low state voltage in register **286**, and at the same time it loads a high state voltage in register **288** to activate the open switch **284**. This latter switch is located in a different projection zone than switch **282**, and since switch **284** is open, no current flows. Since switch **282** is now deactivated, no current flows through that switch either.

When the rotation of the meter disk or wheel continues and the projection element reaches the projection zone of switch **284**, it changes its state from open to closed, the voltage at node **292** (V-sense 2) is changed from high state voltage to zero, and the controller unit **182** is awakened and immediately deactivates switch **284** and activates switch **282**. One rotation of the disk or wheel is defined as a state change of switch **282** from open to closed, followed by a state change of switch **284** from open to closed, after which the controller **182** increments the meter revolution count. Since neither switch is ever active and closed in this configuration, the continuous current drain of the sensor circuitry only includes that of the open switch, which is near zero.

Although the invention has been described in terms of preferred embodiments, it will be understood tbat numerous modifications and variations may be made without departing from the true spirit and scope thereof, as set forth in the following claims:

What is claimed is:

1. A scalable and modular fixed-base wireless network system for wide-area metering data collection comprising:
- multiple meter modules for monitoring, storing, encoding and periodically transmitting metering data;
- multiple base stations for receiving, decoding, storing and forwarding metering data; and
- a data operations center, which communicates with said receiver base station and receives decoded metering data from the base station, said data operations center processing, validating and storing metering data in a database that it maintains for meter modules operating in the network system, wherein:
- the number of base stations being selected in accordance with frequency channels used in the network system and meter module message bit rate to optimize message delivery probability, metering data latency and meter module battery life.

2. The network system of claim **1**, wherein said data operations center is connected to export or forward metering data.

3. The network system of claim **1**, wherein said multiple meter modules includes a direct sequence spread spectrum radio frequency transmitter for transmitting metering data messages via radio signals.

4. The network system of claim **3**, wherein said radio frequency is between 800 MHz and 1000 MHz.

5. The network system of claim **1**, wherein said multiple meter modules include a one-way meter module.

6. The network system of claim **1**, wherein said multiple meter modules include a two-way meter module.

7. The network system of claim **6**, further including a wireless downlink channel to provide service to two-way meter modules that may be operating in the network, enabling time synchronization and other commands to be sent to two-way meter modules.

8. The network system of claim **1**, wherein at least one of said multiple meter modules is a one-way meter module and at least one is a two-way meter module.

9. The network system of claim **1**, wherein said metering data includes interval consumption data.

10. The network system of claim **1**, further including at least one network transceiver/relay device to enhance network coverage in an area of poor or no initial coverage, said at least one transceiver/relay device operating to retransmit messages only from designated meter modules, identified either by module identification number or by an appropriate flag in the transmitted metering data.

11. A scalable and modular fixed-base wireless network system for wide-area metering data collection comprising:
- at least one meter module for monitoring, storing, encoding and periodically transmitting metering data;
- at least one base station for receiving, decoding, storing and forwarding metering data; and
- a data operations center, which communicates with said receiver base station and receives decoded metering data from the base station, said data operations center processing, validating and storing metering data in a database that it maintains for meter modules operating in the network system, wherein:
- said at least one meter module includes sensor means, data storage and processing means, a direct sequence spread spectrum transmitter, and an antenna, all within the same physical enclosure, and
- said at least one meter module further includes a power supply in which a capacitive element and a limited current source are combined to allow high output power during a short transmission burst, the capacitive element and the limited current source imposing a physical limitation on the charge time of the capacitive element and thus the transmission duty cycle to reduce interference that may be caused by a malfunctioning meter module.

12. The network system of claim **11**, wherein said sensing means comprises two sensors to detect rotation, located so that at any given time, no more than one sensor may be at a closed switch status.

13. The network system of claim **12**, where said meter module further includes circuitry for each of said sensors, said circuitry being responsive to a closed switch status of a sensor to immediately disable circuitry corresponding to the sensor having the closed switch status while simultaneously enabling circuitry corresponding to the other switch, whereby near zero current is drawn by the sensors at all times.

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(54) **SYSTEMS AND METHODS FOR MONITORING AND CONTROLLING REMOTE DEVICES**

(75) Inventors: **Thomas David Petite**, Atlanta, GA (US); **Richard M Huff**, Conyers, GA (US)

(73) Assignee: **Sipco, LLC**, Atlanta, GA (US)

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(63) Continuation of application No. 12/337,739, filed on Dec. 18, 2008, now Pat. No. 7,978,059, which is a continuation of application No. 11/395,685, filed on Mar. 31, 2006, now Pat. No. 7,468,661, which is a continuation of application No. 10/139,492, filed on May 6, 2002, now Pat. No. 7,053,767, which is a continuation of application No. 09/439,059, filed on Nov. 12, 1999, now Pat. No. 6,437,692, which is a continuation-in-part of application No. 09/271,517, filed on Mar. 18, 1999, now abandoned, which is a continuation-in-part of application No. 09/102,178, filed on Jun. 22, 1998, now Pat. No. 6,430,268, which is a continuation-in-part of application No. 09/412,895, filed on Oct. 5, 1999, now Pat. No. 6,218,953, which is a continuation-in-part of application No. 09/172,554, filed on Oct. 14, 1998, now Pat. No. 6,028,522.

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See application file for complete search history.

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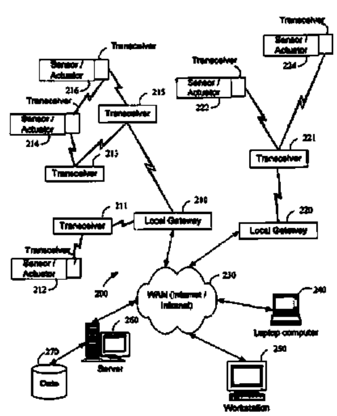
Primary Examiner — Toan N Pham

(74) *Attorney, Agent, or Firm* — Trenton A. Ward; Dustin B. Weeks; Troutman Sanders, LLC

(57) **ABSTRACT**

Embodiments of the present invention are generally directed to a system for monitoring a variety of environmental and/or other conditions within a defined remotely located region. Such a system may be configured to monitor utility meters in a defined area. The system is implemented by using a plurality of wireless transmitters, wherein each wireless transmitter is integrated into a sensor adapted to monitor a particular data input. The system also includes a plurality of transceivers that are dispersed throughout the region at defined locations. The system uses a local gateway to translate and transfer information from the transmitters to a dedicated computer on a network. The dedicated computer, collects, compiles, and stores the data for retrieval upon client demand across the network. The computer further includes means for evaluating the received information and identifying an appropriate control signal, the system further including means for applying the control signal at a designated actuator. Other aspects, features, and embodiments are also claimed and described.

35 Claims, 18 Drawing Sheets



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90-010509 Non-Final Office Action dated Mar. 3, 2010.
90-010505 Final Office Action dated Aug. 2, 2010.
90-010507 Final Office Action dated Aug. 2, 2010.
90-010508 Final Office Action dated Aug. 2, 2010.
90-010509 Final Office Action dated Aug. 2, 2010.
90-010510 Final Office Action dated Aug. 20, 2010.
90-010511 Final Office Action dated Aug. 20, 2010.
90-010512 Final Office Action dated Aug. 20, 2010.
90-010301 Final Office Action dated Nov. 5, 2010.
90-010510 Final Office Action dated Nov. 5, 2010.
90-010511 Final Office Action dated Nov. 5, 2010.
90-010512 Final Office Action dated Nov. 5, 2010.
90-010510 Non-Final Office Action dated Dec. 2, 2009.
90-010511 Non-Final Office Action dated Dec. 2, 2009.
90-010512 Non-Final Office Action dated Dec. 2, 2009.
90-010301 Notice of Intent to Issue Reexam Certificate dated Dec. 13, 2010.

* cited by examiner

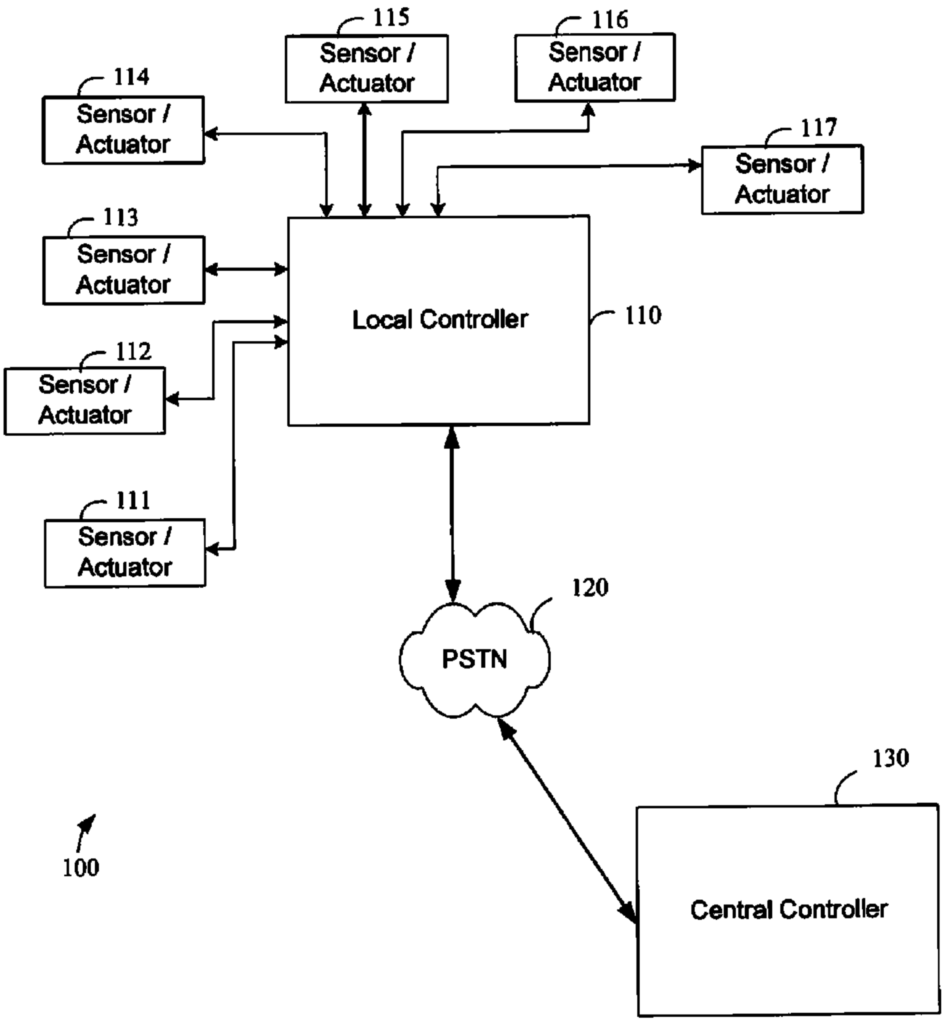

FIG. 1
(PRIOR ART)

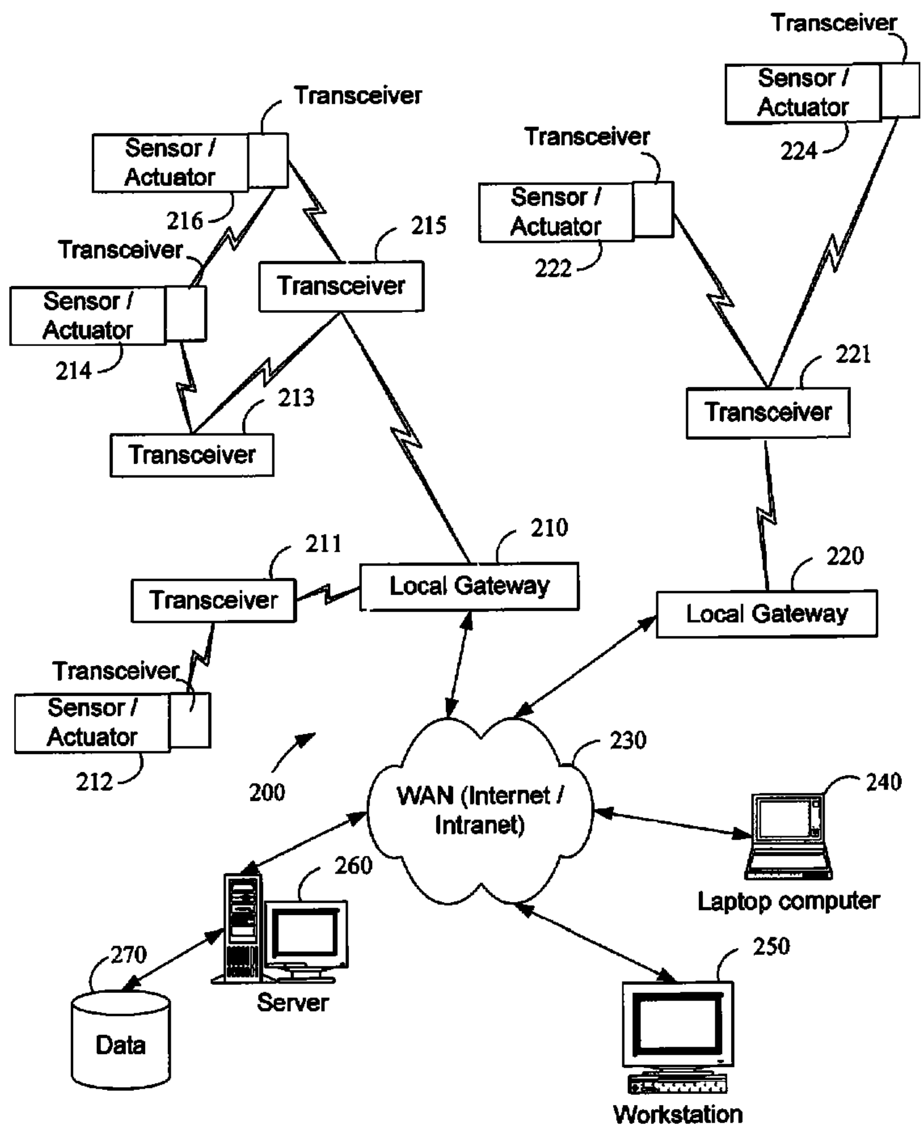
Transceiver
Sensor / Actuator
224
Transceiver
Sensor / Actuator
216
Transceiver
Sensor / Actuator
222
215
Transceiver
Sensor / Actuator
Transceiver
214
221
213
Transceiver
Transceiver
210
211
220
Transceiver
Local Gateway
Local Gateway
Transceiver
Sensor / Actuator
212
200
230
WAN (Internet / Intranet)
240
260
Laptop computer
270
250
Server
Data
Workstation

FIG. 2

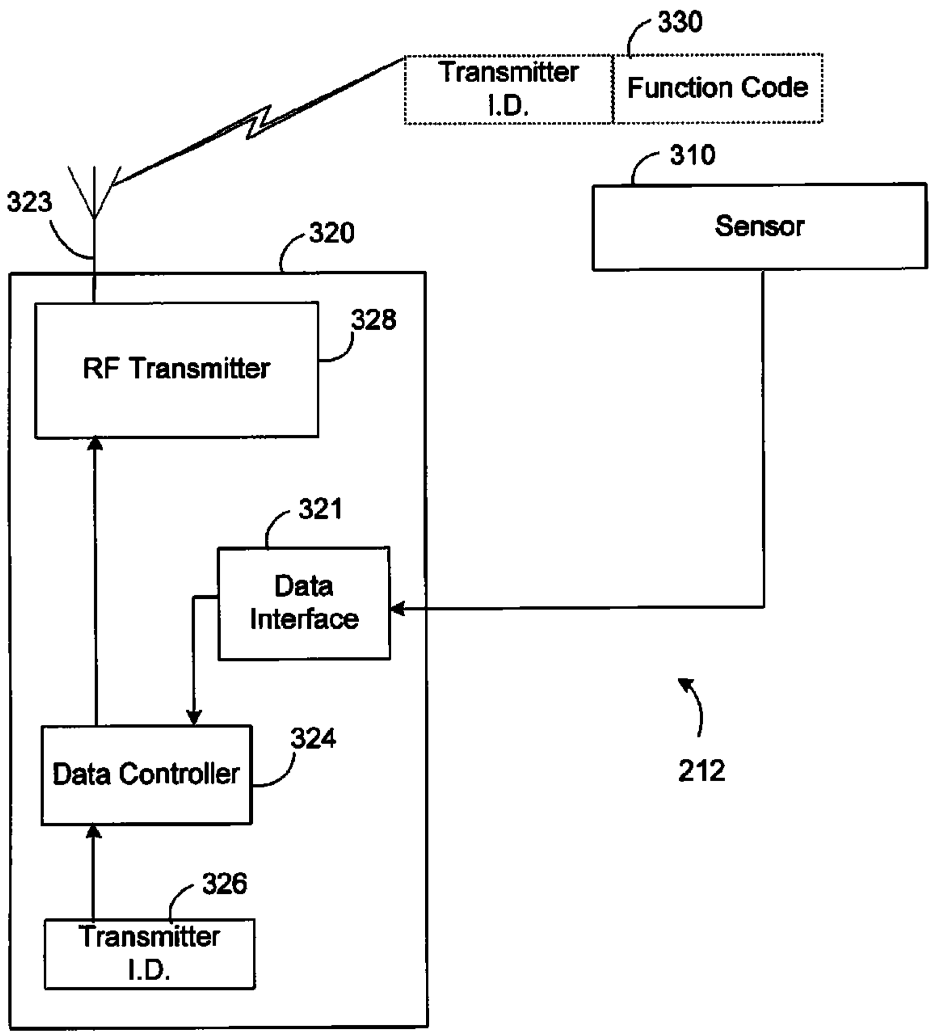
330
Transmitter I.D.
Function Code
310
Sensor
323
320
RF Transmitter
328
321
Data Interface
Data Controller
324
326
Transmitter I.D.
212

FIG. 3A

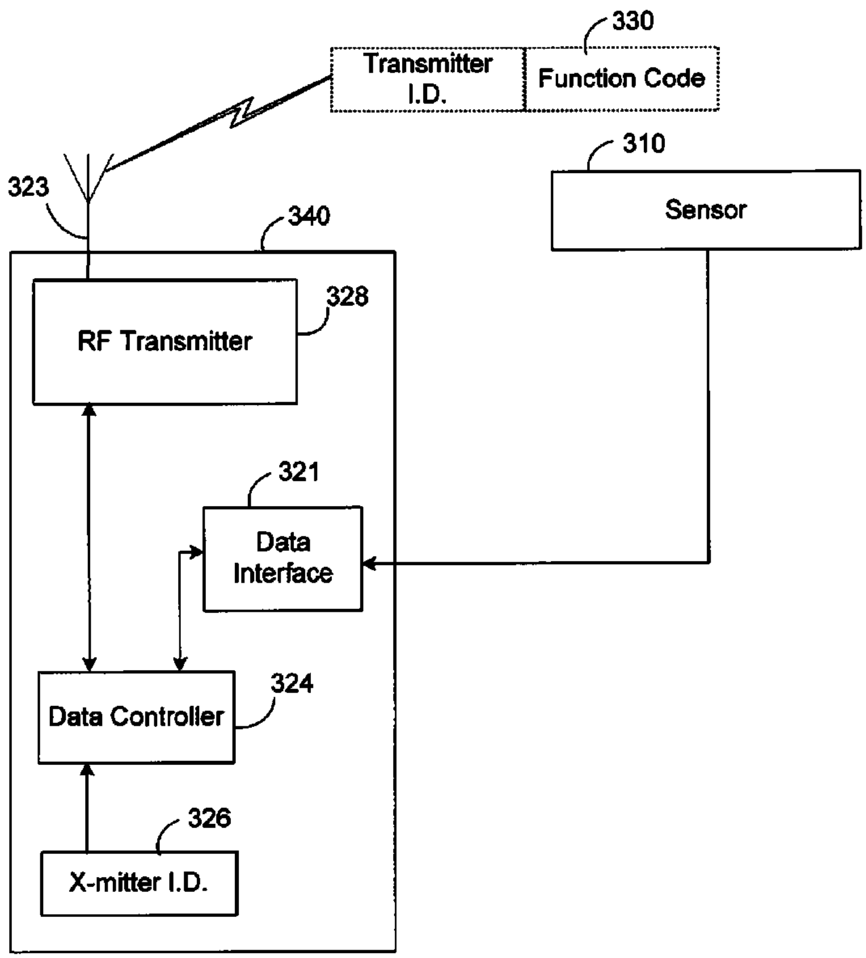
330
Transmitter I.D.
Function Code
310
Sensor
323
340
RF Transmitter
328
321
Data Interface
324
Data Controller
326
X-mitter I.D.

FIG. 3B

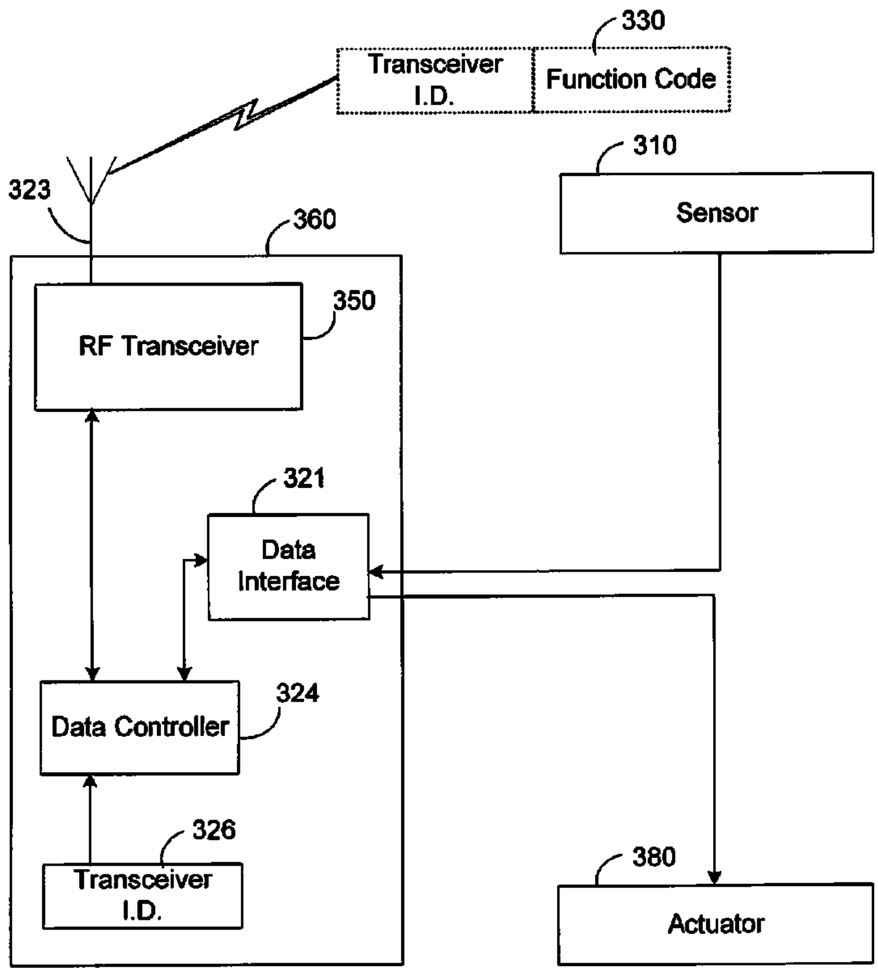
330
Transceiver I.D.
Function Code
310
Sensor
323
360
RF Transceiver
350
321
Data Interface
324
Data Controller
326
Transceiver I.D.
380
Actuator

FIG. 3C

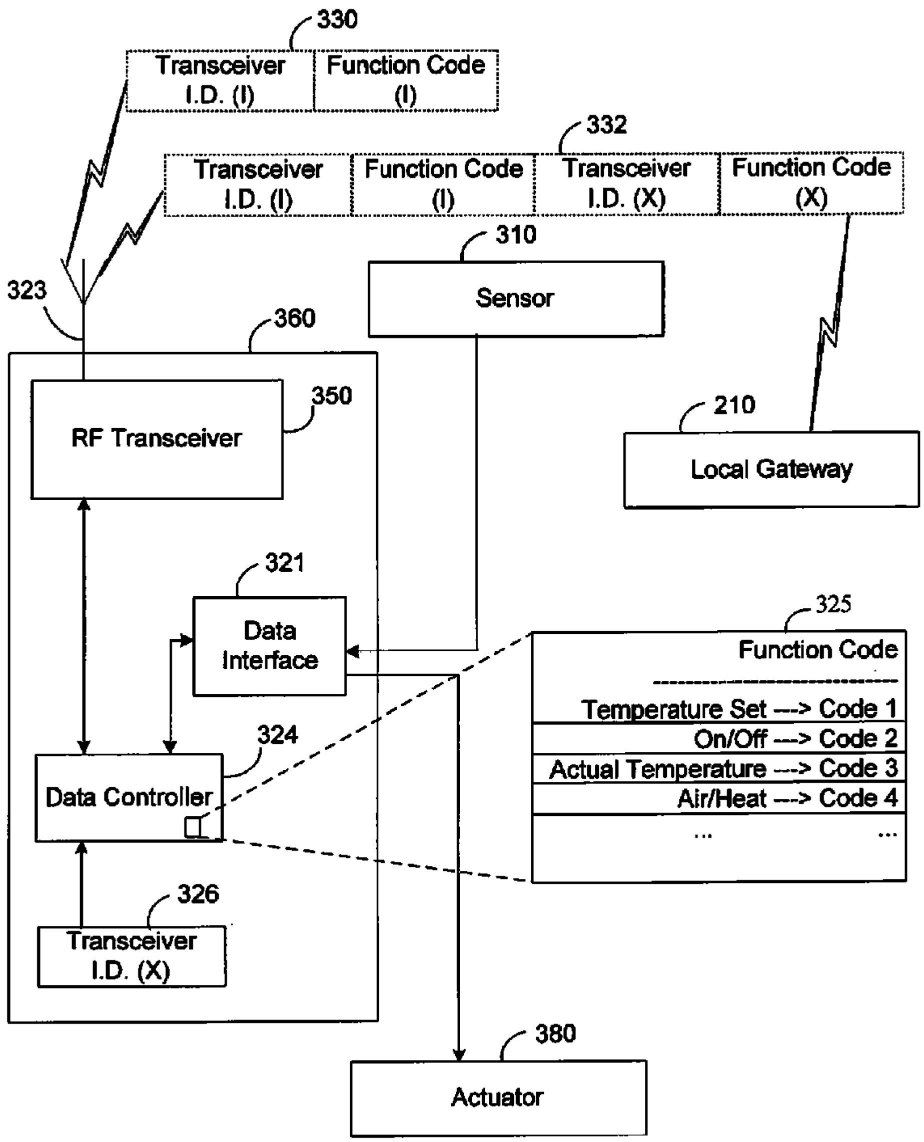
330
Transceiver I.D. (I)
Function Code (I)
332
Transceiver I.D. (I)
Function Code (I)
Transceiver I.D. (X)
Function Code (X)
310
Sensor
323
360
350
RF Transceiver
210
Local Gateway
321
Data Interface
325
Function Code
Temperature Set —> Code 1
On/Off —> Code 2
Actual Temperature —> Code 3
Air/Heat —> Code 4
...
...
324
Data Controller
326
Transceiver I.D. (X)
380
Actuator

FIG. 3D

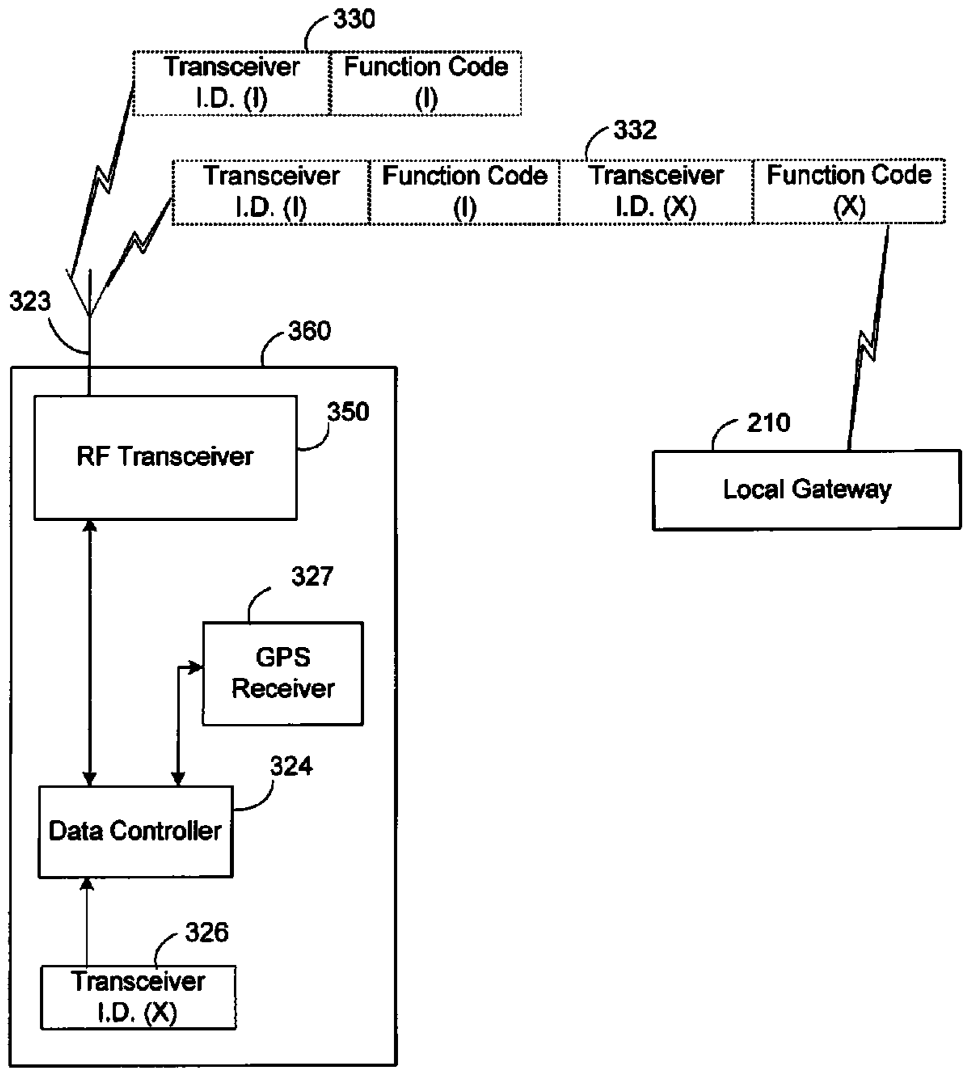
330
Transceiver I.D. (I)
Function Code (I)
332
Transceiver I.D. (I)
Function Code (I)
Transceiver I.D. (X)
Function Code (X)
323
360
350
RF Transceiver
210
Local Gateway
327
GPS Receiver
324
Data Controller
326
Transceiver I.D. (X)

FIG. 3E

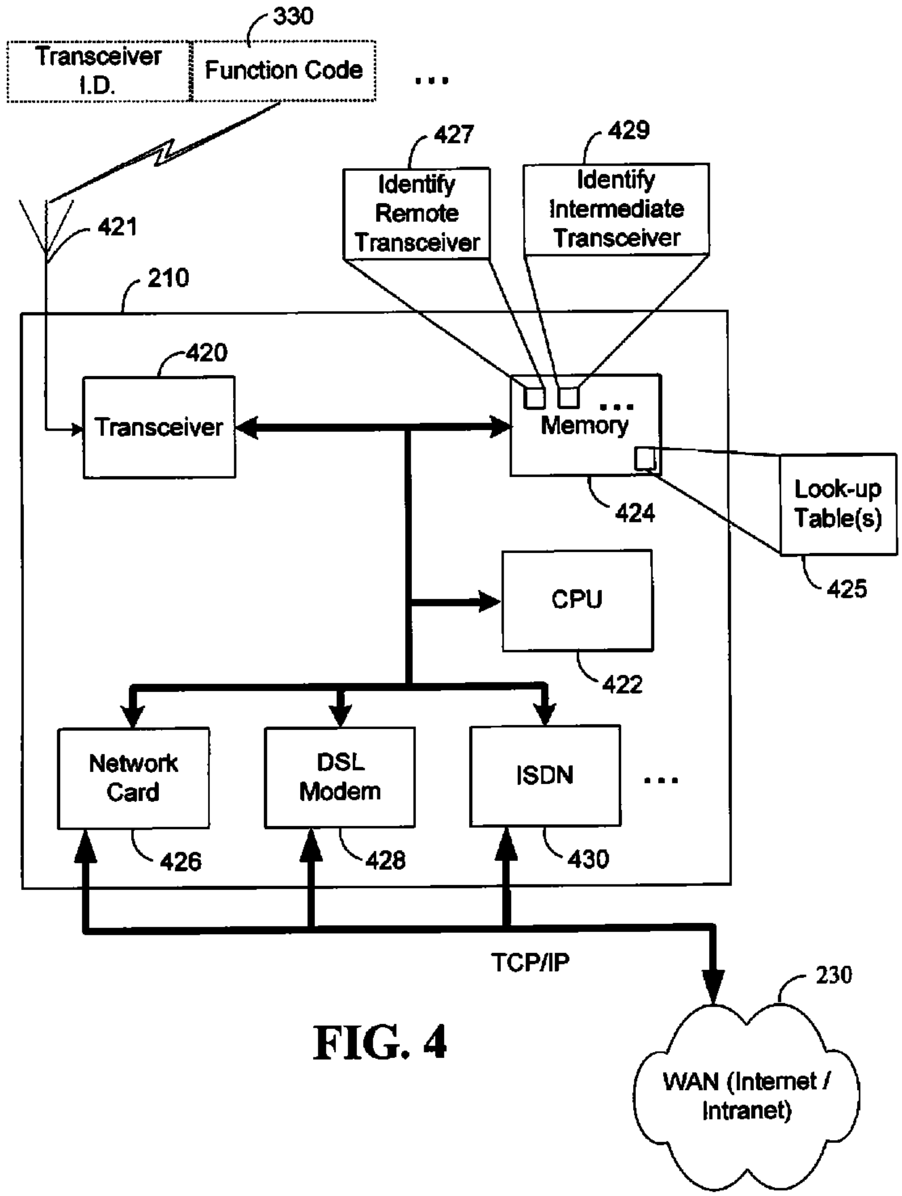
330
Transceiver I.D.
Function Code
...
427
Identify Remote Transceiver
429
Identify Intermediate Transceiver
421
210
420
Transceiver
Memory
...
424
Look-up Table(s)
425
CPU
422
Network Card
426
DSL Modem
428
ISDN
430
...
TCP/IP
230
WAN (Internet / Intranet)

FIG. 4

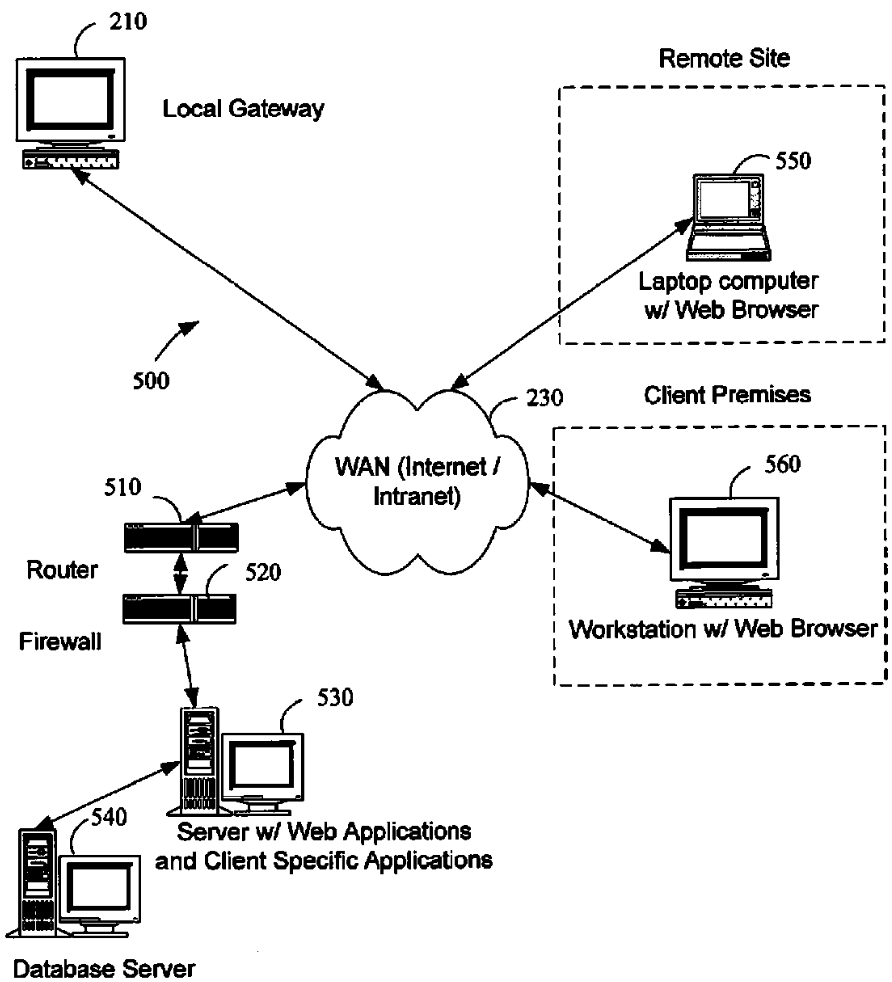
210
Local Gateway
Remote Site
550
Laptop computer
w/ Web Browser
500
230
Client Premises
WAN (Internet / Intranet)
510
560
Router
520
Firewall
Workstation w/ Web Browser
530
540
Server w/ Web Applications
and Client Specific Applications
Database Server

FIG. 5

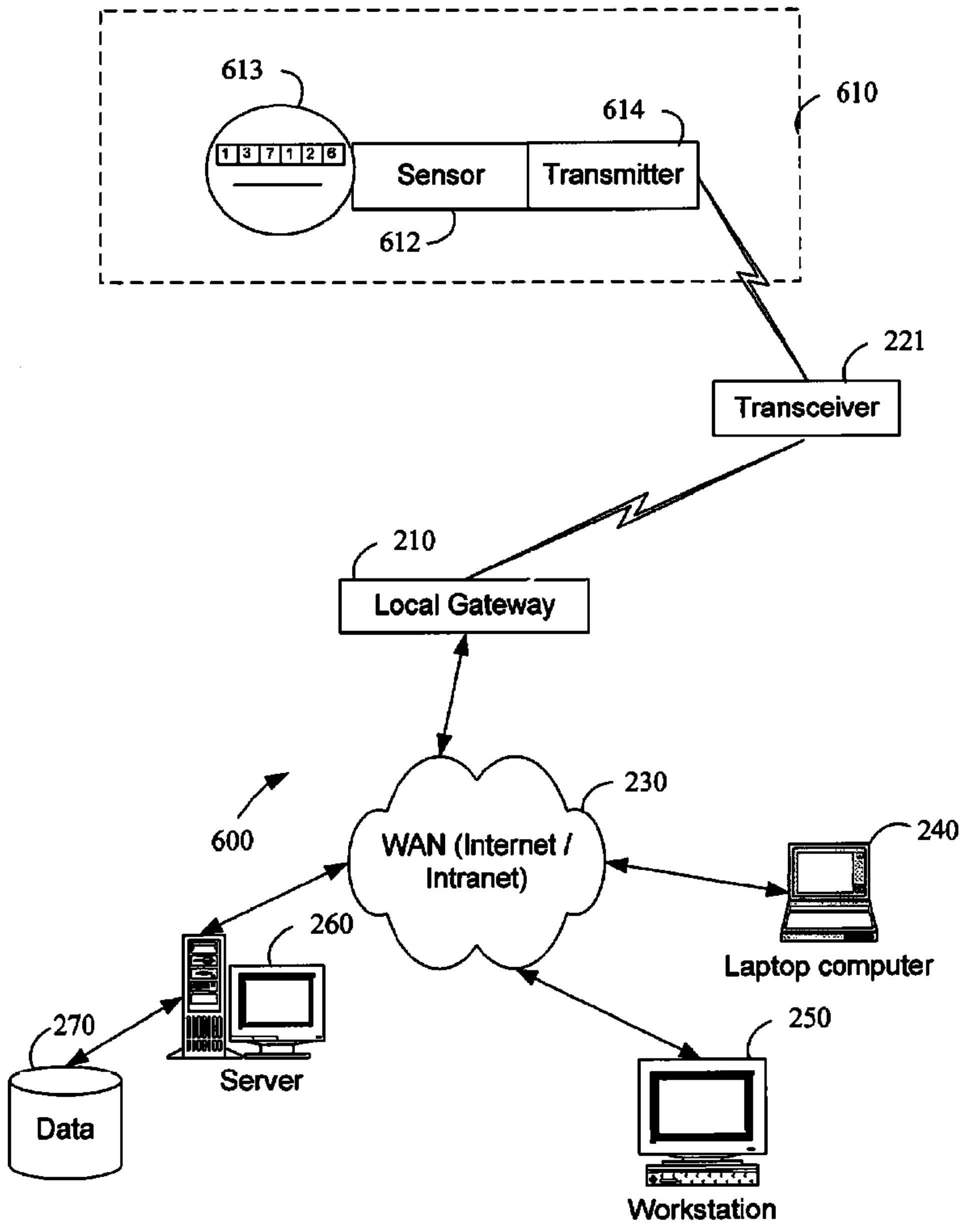
613
610
614
1 3 7 1 2 6
Sensor
Transmitter
612
221
Transceiver
210
Local Gateway
230
600
WAN (Internet / Intranet)
240
Laptop computer
260
270
Server
Data
250
Workstation

FIG. 6

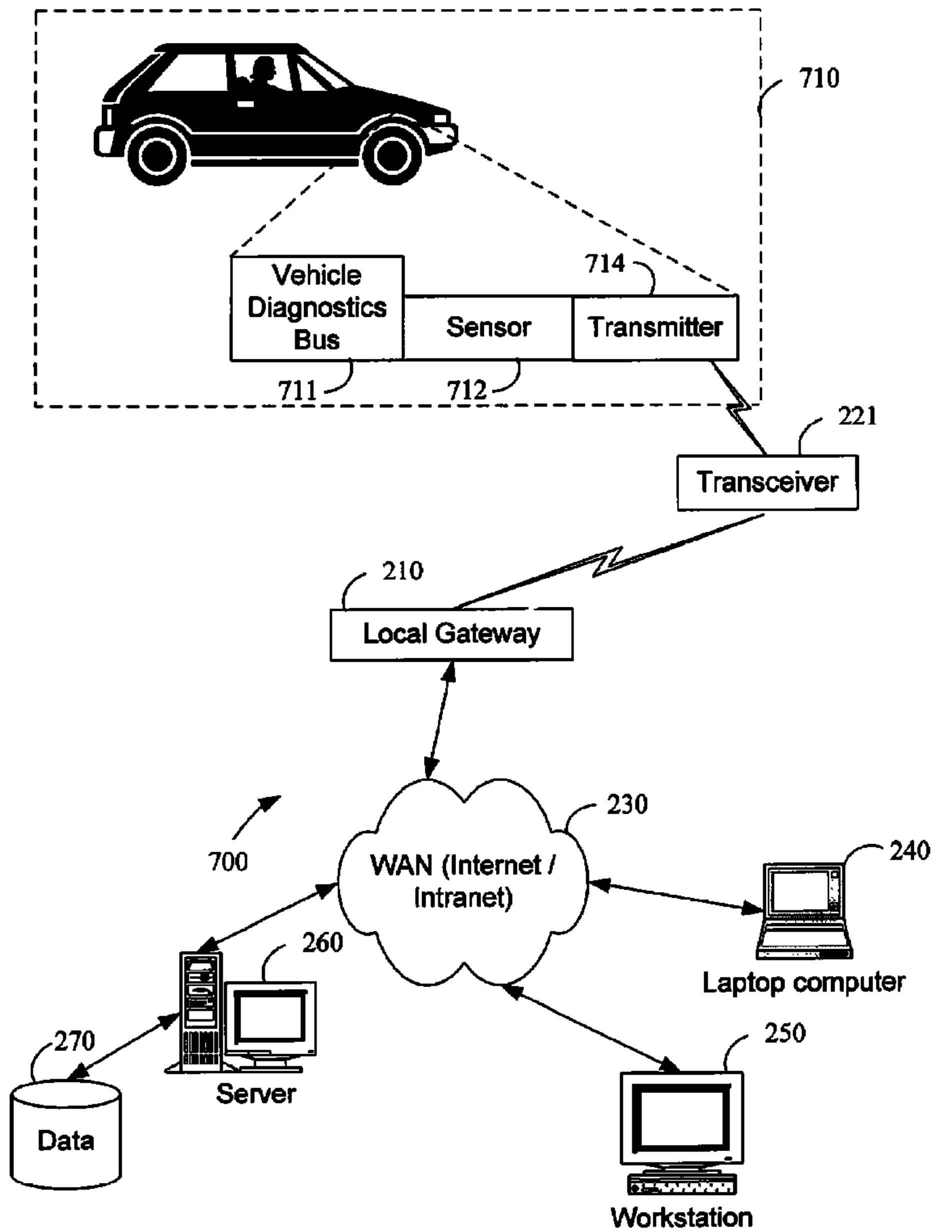
710
Vehicle Diagnostics Bus
Sensor
Transmitter
714
711
712
221
Transceiver
210
Local Gateway
230
WAN (Internet / Intranet)
700
240
Laptop computer
260
270
Server
Data
250
Workstation

FIG. 7

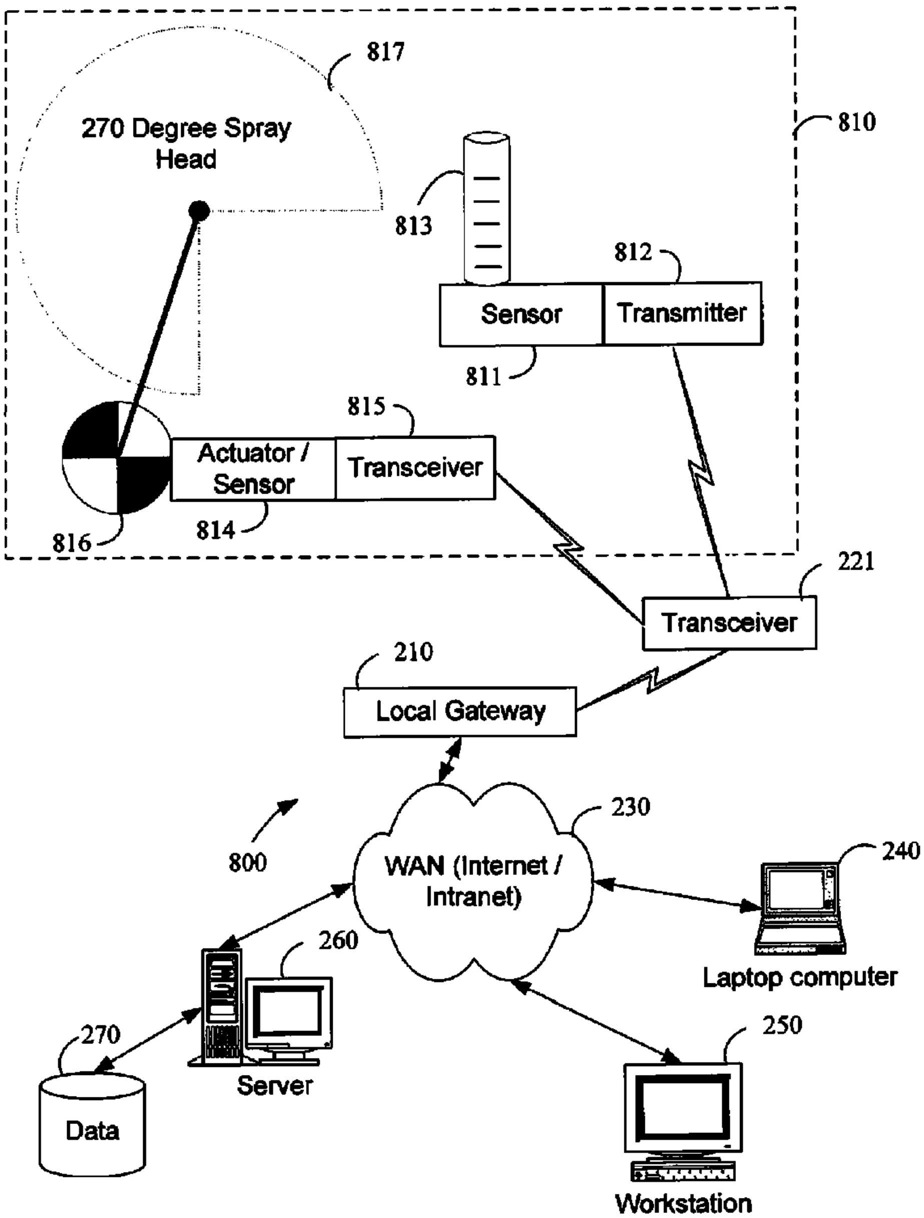
817
270 Degree Spray Head
810
813
812
Sensor
Transmitter
811
815
Actuator / Sensor
Transceiver
814
816
221
Transceiver
210
Local Gateway
230
800
WAN (Internet / Intranet)
240
Laptop computer
260
270
Server
250
Data
Workstation

FIG. 8

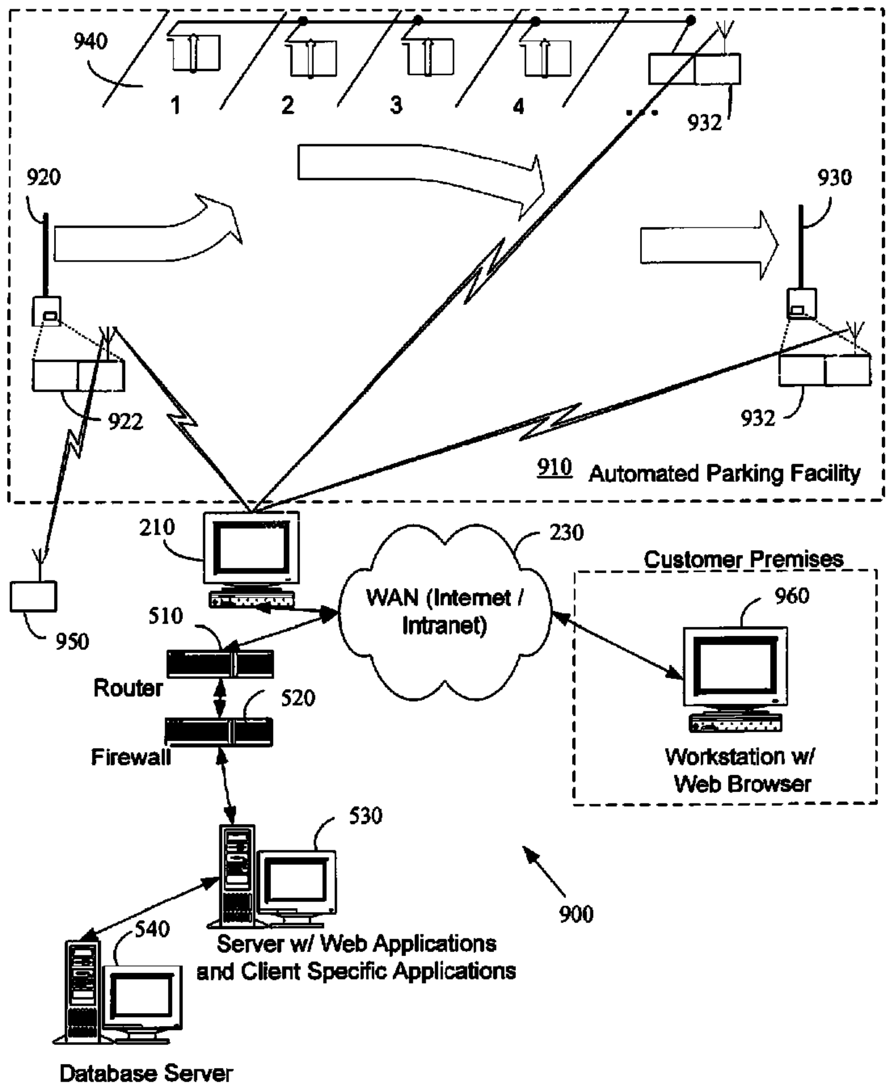
940
1
2
3
4
...
932
920
930
922
932
910 Automated Parking Facility
210
230
WAN (Internet / Intranet)
Customer Premises
960
950
510
Router
520
Firewall
Workstation w/ Web Browser
530
900
540
Server w/ Web Applications and Client Specific Applications
Database Server

FIG. 9

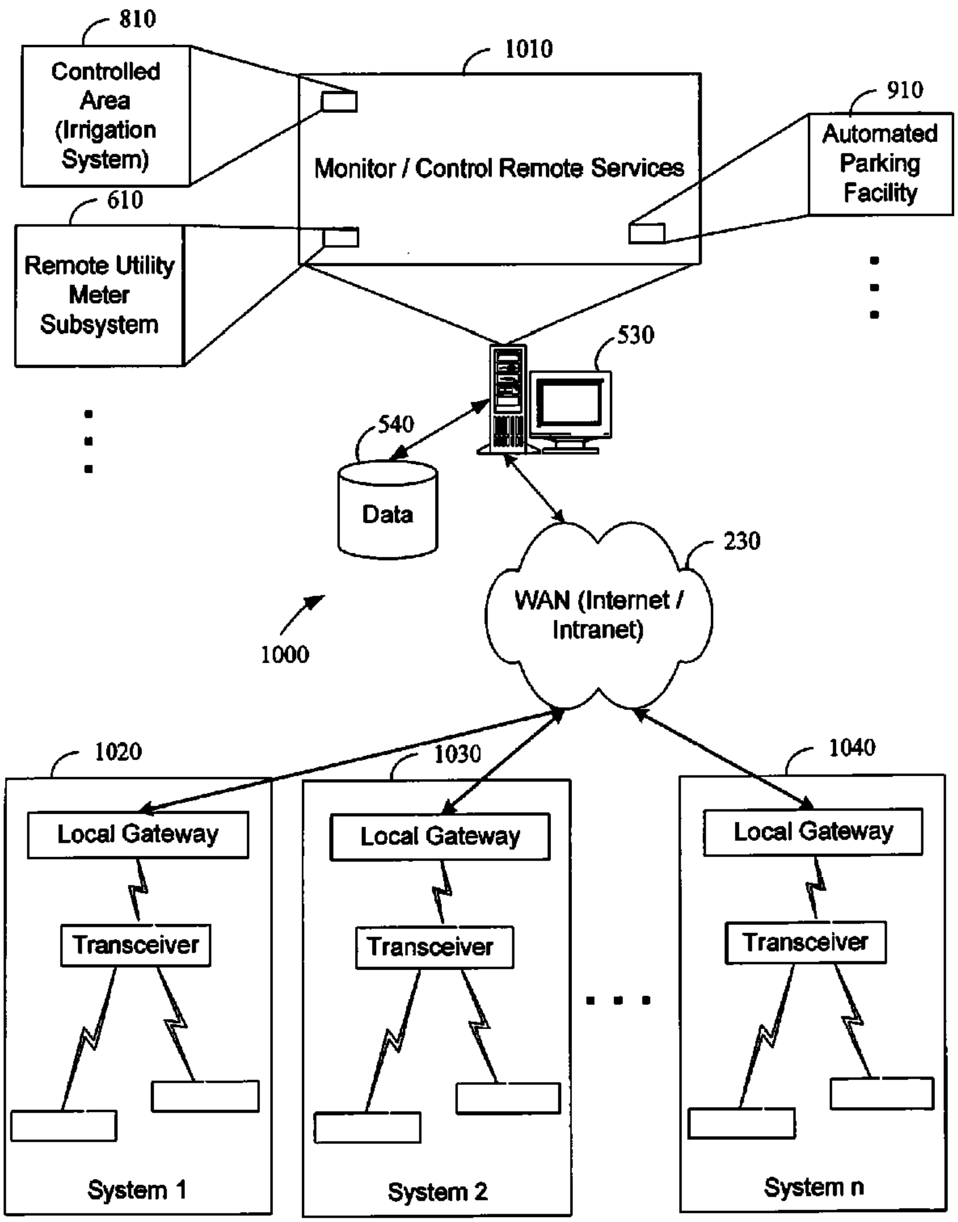
810
Controlled Area (Irrigation System)
1010
Monitor / Control Remote Services
910
Automated Parking Facility
610
Remote Utility Meter Subsystem
530
540
Data
230
WAN (Internet / Intranet)
1000
1020
1030
1040
Local Gateway
Transceiver
System 1
Local Gateway
Transceiver
System 2
Local Gateway
Transceiver
System n

FIG. 10

FIG. 11 Message Structure

To Addr. (1-6)	From Addr. (6)	Pkt. No. (1)	Pkt. Max. (1)	Pkt. Lngth. (1)	Cmd. (1)	Data (0-238)	CkH (1)	CkL (1)

The order of appearance remains fixed although byte position number in each packet may vary due to one or more of the following reasons:

1. Scalability of the "TO ADDRESS" (1 to 6 Bytes).
2. The CMD Byte.
3. Scalability of the Data portion of the message (0 to 238 Bytes).

"To Address" Byte Assignment:

MSB - Byte 1 Device Type	FF-F0 (16) - Broadcast All Devices (1 Byte Address) EF-1F (224) - Device Type Base (2 to 6 Byte Address) 0F-00 (16) - Personal Transceiver Identification (6 Byte Address)
Byte 2 Mfg./Owner ID	FF-F0 (16) - Broadcast all Devices (Byte 1 Type) (2 Byte Broadcast Address) EF-00 (240) - Mfg./Owner Code Identification Number
Byte 3 Mfg./Owner Extension ID	FF-F0 (16) - Broadcast all Devices (Byte 1 & Byte 2 Type) (3 Byte Broadcast Address) EF-00 (240) - Device Type/Mfg./Owner Code ID Number
Byte 4	FF-F0 (16) - Broadcast all Devices (Byte 1 & Byte 2 Type) (4 Byte Broadcast Address) EF-00 (240) - ID Number
Byte 5	(FF-00) 256 - Identification Number
Byte 6	(FF-00) 256 - Identification Number

"From Address" Byte Assignment:

From Address	(FF-00) Full "ID" of Originating Device (up to 6 Bytes)
Packet Number	(FF-00) Packet Number of Msg. longer than 256 Bytes
Packet Max.	(FF-00) Number of Packets in Message over 256 Bytes
Packet Length	(FF-00) Length (in Bytes) of Packet/Message Transmission*
Command	(FF-00) Command Byte
Data	(FF-00) Data as required by specific command
ChkH	(FF-00) Packet Checksum, High Byte
ChkL	(FF-00) Packet Checksum, Low Byte

* Packet Length - 13 Bytes (Min.) / 256 Bytes (Max.)

Sample Messages

Central Server to Personal Transceiver - Broadcast Message - FF (Emergency)

Byte Count = 12

To Addr.	From Addr.	Pkt. No.	Pkt. Max.	Pkt. Lngth.	Cmd.	CkH	CkL
(FF)	(12345678)	(00)	(00)	(0C)	(FF)	(02)	(9E)

First Transceiver to Repeater (Transceiver)
Broadcast Message - FF (Emergency)

Byte Count = 17

To Addr.	From Addr.	Pkt. No.	Pkt. Max.	Pkt. Lngth.	Cmd.		CkH	CkL
(F0)	(12345678)	(00)	(00)	(11)	(FF)		(03)	(A0)

Data
(A000123456)

Note: Additional Transceiver Re-Broadcasts do not change the message.
The messages are simply received and re-broadcast.

Message to Device "A0" From Device "E1" Command - "08" (Respond to PING)
Response will reverse "To" and "From" Addresses

Byte Count = 17

To Addr.	From Addr.	P #	P Max.	P Lngth.	Cmd.	Data	CkH	CkL
(A012345678)	(E112345678)	(00)	(00)	(11)	(08)	(A5)	(04)	(67)

FIG. 12

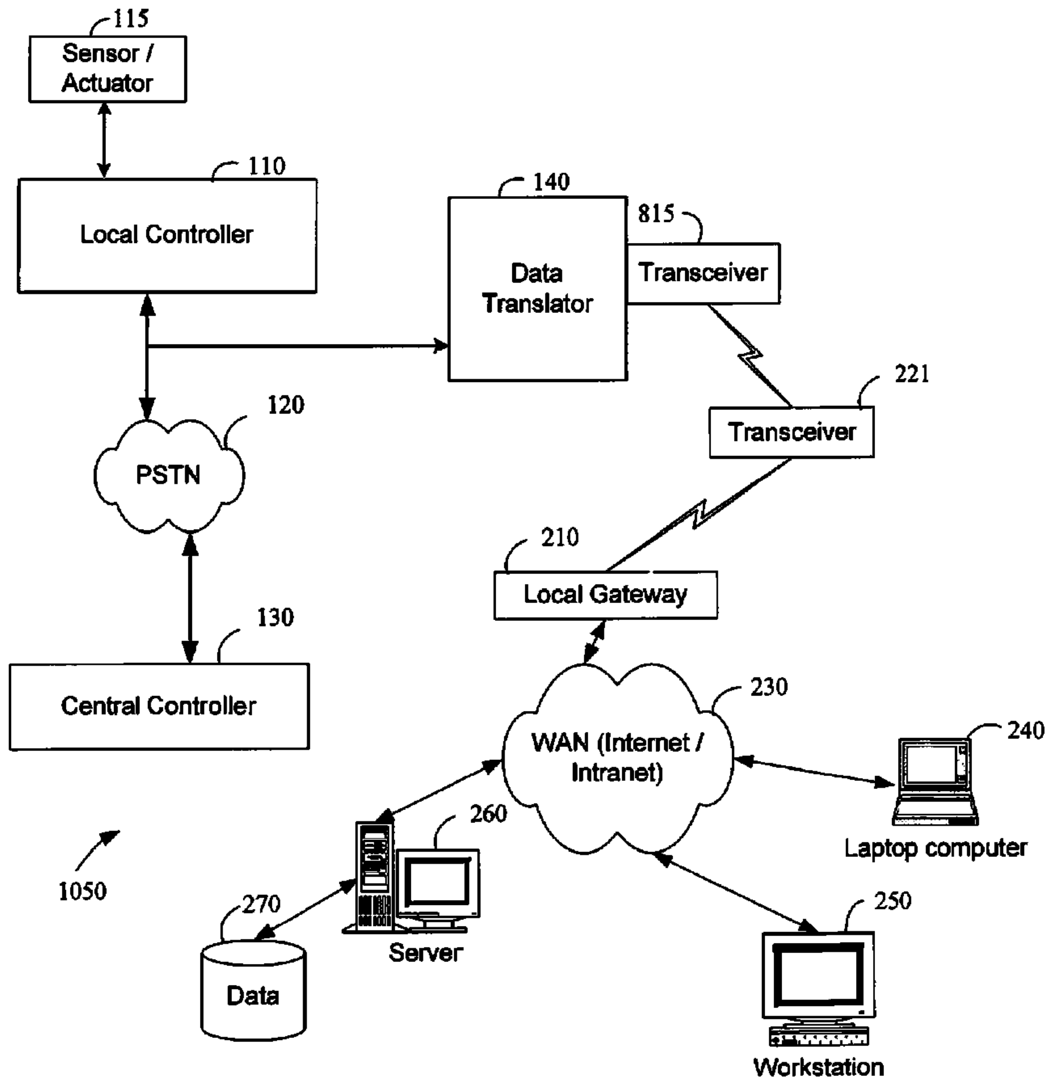
115
Sensor / Actuator
110
Local Controller
140
Data Translator
815
Transceiver
221
Transceiver
120
PSTN
210
Local Gateway
130
Central Controller
230
WAN (Internet / Intranet)
240
Laptop computer
260
Server
270
Data
250
Workstation
1050

FIG. 13

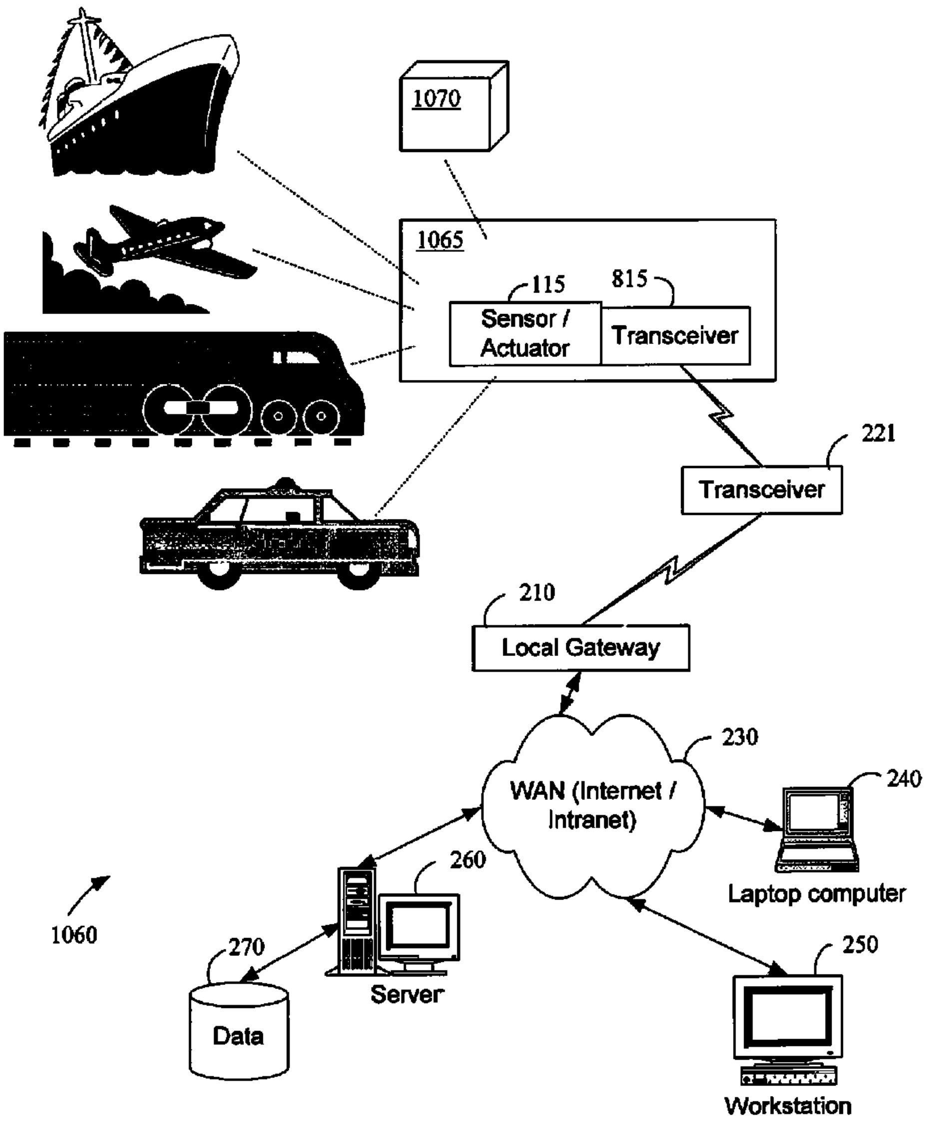
1070
1065
115
815
Sensor / Actuator
Transceiver
221
Transceiver
210
Local Gateway
230
WAN (Internet / Intranet)
240
Laptop computer
260
Server
270
Data
250
Workstation
1060

FIG. 14

SYSTEMS AND METHODS FOR MONITORING AND CONTROLLING REMOTE DEVICES

CROSS REFERENCE TO RELATED APPLICATIONS & PRIORITY CLAIMS

This application is a continuation of U.S. patent application Ser. No. 12/337,739, entitled System and Method for Monitoring and Controlling Remote Devices and filed on 18 Dec. 2008 now U.S. Pat. No. 7,978,059; which is a continuation of U.S. patent application Ser. No. 11/395,685, entitled, "System and Method for Monitoring and Controlling Remote Devices," filed on Mar. 31, 2006, issued as U.S. Pat. No. 7,468,661; which is a continuation of U.S. patent application Ser. No. 10/139,492, entitled, "System and Method for Monitoring and Controlling Remote Devices," filed on May 6, 2002 and now U.S. Pat. No. 7,053,767; which is a continuation of U.S. patent application Ser. No. 09/439,059, filed on Nov. 12, 1999 and entitled "System and Method for Monitoring and Controlling Remote Devices," now U.S. Pat. No. 6,437,692. U.S. Pat. No. 6,437,692 is a continuation-in-part of U.S. patent application Ser. No. 09/271,517, filed Mar. 18, 1999 now abandoned and entitled, "System for Monitoring Conditions in a Residential Living Community", which is a continuation-in-part of U.S. patent application Ser. No. 09/102,178 filed Jun. 22, 1998 and entitled, "Multi-Function General Purpose Transceiver," now U.S. Pat. No. 6,430,268, which is a continuation-in-part of U.S. patent application Ser. No. 09/412,895, filed Oct. 5, 1999 and entitled, "System and Method for Monitoring the Light Level Around an ATM," now U.S. Pat. No. 6,218,953; which is a continuation-in-part of U.S. patent application Ser. No. 09/172,554, filed Oct. 14, 1998 and entitled, "System for Monitoring the Light Level Around an ATM," now U.S. Pat. No. 6,028,522; and further claims the benefit of U.S. Provisional application Ser. No. 60/146,817, filed Aug. 2, 1999 and entitled, "System and Method for Monitoring and Controlling Residential Devices." Each of the above identified applications and patents are incorporated herein by reference in their entireties.

TECHNICAL FIELD

Embodiments of the present invention generally relate to remotely operated systems, and more particularly to a computerized system for monitoring, reporting on, and controlling remote systems by transferring information signals through a wide area network (WAN) and using software applications hosted on a connected server to appropriately process the information.

BACKGROUND

As is known, there are a variety of systems for monitoring and controlling manufacturing processes, inventory systems, emergency control systems, and the like. Most automatic systems use remote sensors and controllers to monitor and automatically respond to system parameters to reach desired results. A number of control systems utilize computers to process system inputs, model system responses, and control actuators to implement process corrections within the system. Both the electric power generation and metallurgical processing industries have had success controlling production processes by implementing computer controlled control systems in individual plants.

One way to classify control systems is by the timing involved between subsequent monitoring occurrences. Monitoring processes can be classified as aperiodic or random, periodic, and real-time. A number of remotely distributed service industries implement the monitoring and controlling process steps through manual inspection and intervention.

A periodic monitoring systems (those that do not operate on a predetermined cycle) are inherently inefficient as they require a service technician to physically traverse an area to record data, repair out of order equipment, add inventory to a vending machine, and the like. Such service trips are carried out in a number of industries with the associated costs being transferred to the consumers of the service.

Conversely, utility meter monitoring, recording, and client billing are representative of a periodic monitoring system. In the past, utility providers sent a technician from meter to meter on a periodic basis to verify meter operation and to record utility use. One method of cutting operating expenses in the utility industry involved increasing the period at which manual monitoring and meter data recording was performed. While this method decreased the monitoring and recording expense associated with more frequent meter observation and was convenient for consumers who favor the consistent billed amounts associated with "budget billing," the utility provider retained the costs associated with less frequent meter readings and the processing costs associated with reconciling consumer accounts.

Lastly, a number of environmental and safety systems require constant or real-time monitoring. Heating, ventilation, and air-conditioning systems, fire reporting and damage control systems, alarm systems, and access control systems are representative systems that utilize real-time monitoring and often require immediate feedback and control. These real-time systems have been the target of control systems theory and application thereof for some time.

A problem with expanding the use of control systems technology to distributed systems are the costs associated with the sensor-actuator infrastructure required to monitor and control functions within such systems. The typical approach to implementing control system technology is to install a local network of hard-wired sensors and actuators along with a local controller. Not only is there expense associated with developing and installing appropriate sensors and actuators but the added expense of connecting functional sensors and controllers with the local controller. Another prohibitive cost associated with applying control systems technology to distributed systems is the installation and operational expense associated with the local controller.

Accordingly, an alternative solution to applying monitoring and control system solutions to distributed systems that overcomes the shortcomings of the prior art is desired.

SUMMARY OF EXEMPLARY EMBODIMENTS

Certain objects, advantages and novel features of the invention will be set forth in part in the description that follows and in part will become apparent to those skilled in the art upon examination of the following or may be learned with the practice of the invention. The objects and advantages of the invention may be realized and obtained by means of the instrumentalities and combinations particularly pointed out in the appended claims.

To achieve the advantages and novel features, the present invention is generally directed to a cost effective method of monitoring and controlling remote devices. More specifically, the present invention is directed to a computerized system for monitoring, reporting, and controlling remote systems and system information transfer by transmitting information signals to a WAN gateway interface and using appli-

cations on a connected server to process the information. Because the applications server is integrated on a WAN, Web browsers can be used by anyone with Internet access (and the appropriate access permissions) to view and download the recorded data.

In accordance with a broad aspect of the invention, a system is provided having one or more sensors to be read and/or actuators to be controlled remotely, ultimately through a computer on the Internet. The sensors and/or actuators are interfaced with wireless transceivers that transmit and/or receive data to and from the Internet. In this regard, additional wireless transceivers may relay information between the transceivers disposed in connection with the sensors and actuators and a gateway to the Internet. It should be appreciated that, a portion of the information communicated includes data that uniquely identifies the sensors and/or actuators.

In accordance with one aspect of the invention, a system is configured to monitor and report system parameters. The system is implemented by using a plurality of wireless transceivers. At least one wireless transceiver is interfaced with a sensor, transducer, actuator or some other device associated with the application parameter of interest. In this regard, the term "parameter" is broadly construed and may include, but is not limited to, a system alarm condition, a system process variable, an operational condition, etc. The system also includes a plurality of transceivers that act as signal repeaters that are dispersed throughout the nearby geographic region at defined locations. By defined locations, it is meant only that the location of each transceiver is known to a central computer. The central computer may be informed of transceiver physical locations after permanent installation, as the installation location of the transceivers is not limited. Each transceiver that serves to repeat a previously generated data signal may be further integrated with its own unique sensor or a sensor actuator combination as required. Additional transceivers may be configured as stand-alone devices that serve to simply receive, format, and further transmit system data signals. Further, the system includes a local data formatter that is configured to receive information communicated from the transceivers, format the data, and forward the data via the gateway to one or more servers interconnected with the WAN. The server further includes means for evaluating the received information and identifying the system parameter and the originating location of the parameter. The server also includes means for updating a database or further processing the reported parameters.

Consistent with the broader concepts of the invention, the "means" for evaluating the received information and the "means" for reporting system parameters are not limited to a particular embodiment or configuration. Preferably, these "means" will be implemented in software that is executed by a processor within a server integrated with the Internet. However, dedicated WANs or Intranets are suitable backbones for implementing defined system data transfer functions consistent with the invention.

In one embodiment, a client retrieves configured system data by accessing an Internet Web site. In such an embodiment, a system consistent with the present invention acts as a data collector and formatter with data being delivered upon client request, with availability twenty-four hours a day, seven days a week.

In more robust embodiments, a system can be configured to collect, format, and deliver client application specific information on a periodic basis to predetermined client nodes on the WAN. In these embodiments, client intervention would serve to close the feedback loop in the control system.

In yet another embodiment, a system can be configured to collect, format, and control client application specific processes by replacing a local control computer with a WAN interfaced server and integrating system specific actuators with the aforementioned system transceivers.

It should be further appreciated that the information transmitted and received by the wireless transceivers may be further integrated with other data transmission protocols for transmission across telecommunications and computer networks other than the Internet. In addition, it should be further appreciated that telecommunications and computer networks other than the Internet can function as a transmission path between the networked wireless transceivers, the local gateways, and the central server.

In yet a further embodiment, a system can be configured using the present invention to translate and transmit control signals from an existing local controller via the networked wireless transceivers. In this regard, the system of the present invention would require a data translator to tap into the data stream of an existing control system. Distinct control system signals may be mapped to function codes used by the present invention in order to provide customer access to control system data. In this way, the system of the present invention can be integrated with present data collection and system controllers inexpensively, as customers will only have to add a data translator and a wireless transmitter or transceiver as the application demands. By integrating the present invention with the data stream generated by present monitoring and control systems, potential customers enjoy the benefits of the present invention without the difficulties associated with integrating sensors and actuators to monitor individual system parameters.

BRIEF DESCRIPTION OF FIGURES

The accompanying drawings incorporated in and forming a part of the specification, illustrate several aspects of the present invention, and together with the description serve to explain the principles of the invention. In the drawings:

FIG. 1 is a block diagram of a prior art control system;

FIG. 2 is a block diagram illustrating a monitoring/control system of the present invention;

FIG. 3A is a functional block diagram that illustrates a transmitter in accordance with the present invention integrated in a portable device with user operable buttons that trigger data transmissions as desired;

FIG. 3B is a functional block diagram that illustrates the integration of a sensor with a transmitter in accordance with the invention;

FIG. 3C is a block diagram illustrating a transceiver in accordance with the present invention integrated with a sensor and an actuator;

FIG. 3D is a functional block diagram further illustrating the transceiver of FIG. 3C as applied to a heating, ventilation, and air conditioning system controller;

FIG. 3E is a functional block diagram illustrating the combination of the transceiver of FIG. 3D with a global positioning system (GPS) receiver;

FIG. 4 is a functional block diagram that illustrates the functional components of a local WAN gateway constructed in accordance with the invention;

FIG. 5 is a diagram illustrating WAN connectivity in a system constructed in accordance with the invention;

FIG. 6 is a block diagram illustrating a client specific application in accordance with the invention (simple data collection or monitoring);

FIG. **7** is a block diagram illustrating another data monitoring and reporting application consistent with the present invention;

FIG. **8** is a block diagram illustrating a third client specific application in accordance with the invention (monitoring and controlling a process);

FIG. **9** is a block diagram illustrating the present invention as deployed in a particular business application;

FIG. **10** is a block diagram further illustrating the present invention as deployed in a plurality of business applications;

FIG. **11** is a table illustrating the message protocol of the present invention;

FIG. **12** illustrates three sample messages using the message protocol of the present invention;

FIG. **13** is a block diagram illustrating the system of the present invention integrated with the local controller of FIG. **1**; and

FIG. **14** is a block diagram illustrating the system of the present invention integrated with a mobile inventory unit.

DETAILED DESCRIPTION OF PREFERRED & ALTERNATIVE EMBODIMENTS

Having summarized the invention above, reference is now made in detail to the description of the invention as illustrated in the drawings. While the invention will be described in connection with these drawings, there is no intent to limit it to the embodiment or embodiments disclosed therein. On the contrary, the intent is to cover all alternatives, modifications and equivalents included within the spirit and scope of the invention as defined by the appended claims.

Referring now to the drawings, reference is made to FIG. **1**, which is a block diagram illustrating certain fundamental components of a prior art control system **100**. More particularly, a prior art control system **100** includes a plurality of sensor actuators **111**, **112**, **113**, **114**, **115**, **116**, and **117** electrically coupled to a local controller **110**. In a manner well known in the art of control systems, local controller **110** provides power, formats and applies data signals from each of the sensors to predetermined process control functions, and returns control signals as appropriate to the system actuators. Often, prior art control systems are further integrated via the public switched telephone network (PSTN) **120** to a central controller **130**. Central controller **130** can be further configured to serve as a technician monitoring station or to forward alarm conditions via PSTN **120** to appropriate public safety officers.

Prior art control systems consistent with the design of FIG. **1** require the development and installation of an application-specific local system controller, as well as, the routing of electrical conductors to each sensor and actuator as the application requires. Such prior art control systems are typically augmented with a central controller **130** that may be networked to the local controller **110** via PSTN **120**. As a result, prior art control systems often consist of a relatively heavy design and are subject to a single point of failure should local controller **110** go out of service. In addition, these systems require electrical coupling between the local controller and system sensors and actuators. As a result, appropriately wiring an existing industrial plant can be a dangerous and expensive proposition.

Having described a prior art control system and delineated some of its shortcomings, reference is now made to FIG. **2**, which is a block diagram that illustrates a control system in accordance with the present invention. Control system **200** consists of one or more sensor/actuators **212**, **214**, **216**, **222**, and **224** each integrated with a transceiver. The transceivers are preferably RF (Radio Frequency) transceivers, that are relatively small in size and transmit a relatively low power RF signal. As a result, in some applications, the transmission range of a given transceiver may be relatively limited. As will be appreciated from the description that follows, this relatively limited transmission range of the transceivers is an advantageous and desirable characteristic of control system **200**. Although the transceivers are depicted without a user interface such as a keypad, in certain embodiments of the invention the transceivers may be configured with user selectable buttons or an alphanumeric keypad. Often, the transceivers will be electrically interfaced with a sensor or actuator, such as a smoke detector, a thermostat, a security system, etc., where external buttons are not needed.

Control system **200** also includes a plurality of stand-alone transceivers **211**, **213**, **215**, and **221**. Each stand-alone transceiver **211**, **213**, **215**, and **221** and each of the integrated transceivers **212**, **214**, **216**, **222**, and **224** may be configured to receive an incoming RF transmission (transmitted by a remote transceiver) and to transmit an outgoing signal. This outgoing signal may be another low power RF transmission signal, a higher power RF transmission signal, or alternatively may be transmitted over a conductive wire, fiber optic cable, or other transmission media. The internal architecture of a transceiver integrated with a sensor/actuator **212** and a stand-alone transceiver **211** will be discussed in more detail in connection with FIGS. **3A** through **3C**. It will be appreciated by those skilled in the art that integrated transceivers **212**, **214**, **216**, **222**, and **224** can be replaced by RF transmitters (not shown) for client specific applications that require data collection only.

Local gateways **210** and **220** are configured and disposed to receive remote data transmissions from the various stand-alone transceivers **211**, **213**, **215**, and **221** or integrated transceivers **212**, **214**, **216**, **222**, and **224** having an RF signal output level sufficient to adequately transmit a formatted data signal to the gateways. Local gateways **210** and **220** analyze the transmissions received, convert the transmissions into TCP/IP format and further communicate the remote data signal transmissions via WAN **230**. In this regard, and as will be further described below, local gateways **210** and **220** may communicate information, service requests, control signals, etc. to remote sensor/actuator transceiver combinations **212**, **214**, **216**, **222**, and **224** from server **260**, laptop computer **240**, and workstation **250** across WAN **230**. Server **260** can be further networked with database server **270** to record client specific data.

It will be appreciated by those skilled in the art that if an integrated transceiver (either of **212**, **214**, **216**, **222**, and **224**) is located sufficiently close to local gateways **210** or **220** such that its RF output signal can be received by a gateway, the RF data signal need not be processed and repeated through stand-alone transceivers **211**, **213**, **215**, or **221**.

It will be further appreciated that a monitoring system constructed in accordance with the teachings of the present invention may be used in a variety of environments. In accordance with a preferred embodiment, a monitoring system such as that illustrated in FIG. **2** may be employed to monitor and record utility usage by residential and industrial customers as illustrated in FIG. **6**. Another preferred monitoring system is illustrated in FIG. **7**. FIG. **7** depicts the transfer of vehicle diagnostics from an automobile via a RF transceiver integrated with the vehicle diagnostics bus to a local transceiver that further transmits the vehicle information through a local gateway onto a WAN.

It will be further appreciated that a monitoring and control system consistent with the present invention may be used in a

variety of environments. In accordance with a preferred embodiment, a control system such as that illustrated in FIG. 2 may be employed to monitor and control an irrigation system as illustrated in FIG. 8. Another preferred control system is illustrated in FIG. 9. FIG. 9 depicts a business application of a control system wherein the operation of a parking facility may be automated.

As will be further appreciated from the discussion herein, transceivers **212**, **214**, **216**, **222**, and **224** may have substantially identical construction (particularly with regard to their internal electronics), which provides a cost effective implementation at the system level. Furthermore, a plurality of stand-alone transceivers **211**, **213**, **215**, and **221**, which may be identical, are disposed in such a way that adequate coverage in an industrial plant or community is provided. Preferably, stand-alone transceivers **211**, **213**, **215**, and **221** may be dispersed sufficient that only one stand-alone transceiver will pick up a transmission from a given integrated transceiver **212**, **214**, **216**, **222**, and **224** (due in part to the low power transmission nature of each transmitter). However, in certain instances two, or even more, stand-alone transceivers may pick up a single transmission. Thus, the local gateways **210** and **220** may receive multiple versions of the same data transmission signal from an integrated transceiver, but from different stand-alone transceivers. The local gateways **210** and **220** may utilize this information to triangulate, or otherwise more particularly assess the location from which the transmission is originating. Due to the transmitting device identification that is incorporated into the transmitted signal, duplicative transmissions (e.g., transmissions duplicated to more than one gateway, or to the same gateway, more than once) may be ignored or otherwise appropriately handled.

In accordance with the preferred embodiment shown in FIG. 2, integrated transceivers **212**, **214**, **216**, **222**, and **224** may be disposed within automobiles (see FIG. 7), a rainfall gauge (see FIG. 8), or a parking lot access gate (see FIG. 9) to monitor vehicle diagnostics, total rainfall and sprinkler supplied water, and access gate position, respectively. The advantage of integrating a transceiver, as opposed to a one-way transmitter, into a monitoring device relates to the ability of the transceiver to receive incoming control signals, as opposed to merely transmitting data signals. Significantly, local gateways **210** and **220** may communicate with all system transceivers. Since local gateways **210** and **220** are permanently integrated with WAN **230**, server **260** can host application specific software which was typically hosted in an application specific local controller as shown in FIG. 1. Of further significance, the data monitoring and control devices of the present invention need not be disposed in a permanent location as long as they remain within signal range of a system compatible transceiver that subsequently is within signal range of a local gateway interconnected through one or more networks to server **260**. In this regard, small application specific transmitters compatible with control system **200** can be worn or carried about one's person as will be further described below.

In one embodiment, server **260** collects, formats, and stores client specific data from each of the integrated transceivers **212**, **214**, **216**, **222**, and **224** for later retrieval or access from workstation **250** or laptop **240**. In this regard, workstation **250** or laptop **240** can be used to access the stored information through a Web browser in a manner that is well known in the art. In another embodiment, server **260** may perform the additional functions of hosting application specific control system functions and replacing the local controller by generating required control signals for appropriate distribution via WAN **230** and local gateways **210** and **211** to the system actuators. In a third embodiment, clients may elect for proprietary reasons to host control applications on their own WAN connected workstation. In this regard, database **270** and server **260** may act solely as a data collection and reporting device with client workstation **250** generating control signals for the system.

It will be appreciated by those skilled in the art that the information transmitted and received by the wireless transceivers of the present invention may be further integrated with other data transmission protocols for transmission across telecommunications and computer networks other than the Internet. In addition, it should be further appreciated that telecommunications and computer networks other than the Internet can function as a transmission path between the networked wireless transceivers, the local gateways, and the central server.

Reference is now made to FIG. 3A, which is a block diagram that illustrates the functional components of a RF transmitter **320**, of a type worn or carried by a person, in more detail. Blocks **327** and **329** represent physical buttons, which a user may actuate to cause the RF transmitter **320** to initiate different signal transmissions. In the illustrated embodiment, these include a "transmit" button **327** and a panic or "emergency" button **329**. Of course, additional, fewer, or different buttons may be provided on a given transmitter, depending upon the system or implementation desired. Each of these buttons may be electrically wired to a data interface **321** which is configured to receive electrical signals from buttons **327** and **329**, and ultimately convey that information to a data formatter **324**. In one embodiment, data interface **321** may simply comprise an addressable port that may be read by the data formatter **324**.

For example, each of the signal lines extending between the buttons and the data interface **321** may be pulled up by individual pull up resistors (not shown). Depressing any of the individual buttons may ground the electrical signal line interconnecting the respective button and the data interface **321**. Data formatter **324** may constantly read from the port defined by data interface **321**, and all bit positions should remain high at any given time, if no buttons are depressed. If, however, the data formatter **324** reads a zero in one or more of the bit positions, it then recognizes that one or more of the buttons **327** and **329** have been depressed.

Each transmitter unit may be configured to have a unique identification code (e.g., transmitter identification number) **326**, that uniquely identifies the transmitter to the functional blocks of control system **200** (see FIG. 2). This transmitter identification number may be electrically programmable, and implemented in the form of, for example, an EPROM. Alternatively, the transmitter identification number may be set/configured through a series of DIP switches. Additional implementations of the transmitter identification number, whereby the number may be set/configured, may be implemented consistent with the broad concepts of the present invention.

Finally, an additional functional block of the transmitter **320** is a RF transmitter **328**. This circuit is used to convert information from digital electronic form into a format, frequency, and voltage level suitable for transmission from antenna **323** via an RF transmission medium.

The data formatter **324** operates to format concise data packets **330** that may be transmitted via RF to a nearby transceiver. From a substantive basis, the information conveyed includes a function code, as well as, a transmitter identification number. As previously mentioned, the transmitter identification number is set for a given transmitter **320**. When received by server **260** (see FIG. 2), the transmitter

identification number may be used to access a look up table that identifies, for example, the person assigned to carry that particular transmitter. Additional information about the person may also be provided within the lookup table, such as, a physical description, and/or any other information that may be deemed appropriate or useful under the circumstances or implementation of the particular system.

In addition, a function code is communicated from RF transmitter **320** to the nearby transceiver. FIG. **3A** illustrates a lookup table **325** that may be provided in connection with data formatter **324**. Lookup table **325** may be provided to assign a given and unique function code for each button pressed. For example, transmit button **327** may be assigned a first code to identify the party depressing the button. The emergency button **329** may be assigned a second code. Furthermore, additional codes may be provided as necessary to accommodate additional functions or features of a given transmitter **320**. Thus, in operation, a user may depress the emergency button **329**, which is detected by the data formatter **324**. The data formatter **324** may then use the information pertaining to the emergency button **329** to access a look up table **325** to retrieve a code that is uniquely assigned to emergency button **329**. The data formatter **324** may also retrieve the pre-configured transmitter identification number **326** in configuring a data packet **330** for communication via RF signals to a nearby transceiver.

Reference is now made briefly to FIG. **3B**, which is a block diagram illustrating certain functional blocks of a similar transmitter **340** that may be integrated with sensor **310**. For example, sensor **310** in its simplest form could be a two-state device such as a smoke alarm. Alternatively, the sensor **310** may output a continuous range of values to the data interface **321**. If the signal output from the sensor **310** is an analog signal, the data interface **321** may include an analog-to-digital converter (not shown) to convert signals output to the actuator **340**. Alternatively, a digital interface (communicating digital signals) may exist between the data interface **321** and each sensor **310**.

As illustrated, many of the components of RF transmitter **340** are similar to that of RF transmitter **320** and need not be repeated herein. The principal difference between the configurations of RF transmitter **320** of FIG. **3A** and the RF transmitter **340** of FIG. **3B** lies at the input of the data interface **321**. Specifically, RF transmitter **320** included user interface buttons **327** and **329**. RF transmitter **340**, illustrates electrical integration with sensor **310**. Unique transmitter identification code **326** coupled with a function code for a smoke alarm on condition is formatted by data controller **324** for transformation into a RF signal by RF transmitter **328** and transmission via antenna **323**. In this way, data packet **330** communicated from transmitter **340** will readily distinguish from similar signals generated by other RF transmitters in the system. Of course, additional and/or alternative configurations may also be provided by a similarly configured RF transmitter. For example, a similar configuration may be provided for a transmitter that is integrated into, for example, a carbon monoxide detector, a door position sensor and the like. Alternatively, system parameters that vary across a range of values may be transmitted by RF transmitter **340** as long as data interface **321** and data controller **324** are configured to apply a specific code, consistent with the input from sensor **310**. As long as the code was understood by server **260** or workstation **250** (see FIG. **2**) the target parameter could be monitored with the present invention.

Reference is now made to FIG. **3C**, which is a block diagram similar to that illustrated in FIGS. **3A** and **3B**, but illustrating a transceiver **360** that is integrated with a sensor **310** and an actuator **380**. In this illustration, data interface **321** is shown with a single input from sensor **310**. It is easy to envision a system that may include multiple sensor inputs. By way of example, a common home heating and cooling system might be integrated with the present invention. The home heating system may include multiple data interface inputs from multiple sensors. A home thermostat control connected with the home heating system could be integrated with a sensor that reports the position of a manually adjusted temperature control (i.e., temperature set value), as well as, a sensor integrated with a thermister to report an ambient temperature. The condition of related parameters can be input to data interface **321** as well, including the condition of the system on/off switch, and the climate control mode selected (i.e., heat, fan, or AC). In addition, depending upon the specific implementation, other system parameters may be provided to data interface **321** as well.

The addition of actuator **380** to the assembly permits data interface **321** to apply control signals to the manual temperature control for the temperature set point, the climate control mode switch, and the system on/off switch. In this way, a remote workstation **250** or laptop **240** with WAN access (see FIG. **2**) could control a home heating system from a remote location.

Again, each of these various input sources are routed to data interface **321** which provides the information to a data controller **324**. The data controller may utilize a look up table to access unique function codes that are communicated in data packet **330**, along with a transceiver identification code **326** via RF, to a local gateway and further onto a WAN. In general, the operation of transceiver **360** will be similar to that described for a transmitter as previously illustrated in FIGS. **3A** and **3B**. It is significant to note that data packet **330** will include a concatenation of the individual function codes selected for each of the aforementioned input parameters. As by way of example, server **260** may provide client workstation **250** with a Web page display that models a common home thermostat. As previously described, either server **260** or workstation **250** may include application software that would permit a user with access to remotely adjust the controls on a home heating system by adjusting related functional controls on a graphical user interface updated with feedback from the aforementioned control system.

Reference is now made to FIG. **3D**, which is a block diagram further illustrating the transceiver of FIG. **3C** in light of the home heating system described above. Specifically, transceiver **360** is shown with four specific parameters related to four specific function codes as illustrated in look up table **325**. In this regard, sensor(s) **310** (one sensor shown for simplicity) inputs a data signal to data interface **321**. Data controller receives an input from data interface **321** that it associates with a specific function code as shown in look up table **325**. Data controller **324** assembles data packet **332** by concatenating received data packet **330** with its own transceiver identification code **326** and its own specific function codes. Data packet **332** is configured by RF transceiver **350** for transmission via antenna **323** to either a stand-alone transceiver as shown in FIG. **2**, or alternatively, to local gateway **210**. It will be appreciated by persons skilled in the art that data interface **321** may be uniquely configured to interface with specialized sensor(s) **310**. This circuit, therefore, may differ from transceiver to transceiver, depending upon the remote system parameter that is monitored and the related actuator to be controlled. Implementation of data interface **321** will be understood by persons skilled in the art, and need not be described herein.

Reference is now made to FIG. 3E, which is a block diagram further illustrating the transceiver of FIG. 3C in combination with a GPS receiver. Specifically, GPS receiver **327** replaces data interface **321**, sensor **310**, and actuator **380** as illustrated in FIG. 3C. In this regard, GPS receiver **327** inputs a data signal containing latitude and longitude coordinates to data controller **324**. Data controller **324** assembles data packet **332** by concatenating received data packet **330** with its own transceiver identification code **326** and the coordinates received from GPS receiver **327**. Data packet **332** is configured by RF transceiver **350** for transmission via antenna **323** to either a stand-alone transceiver as shown in FIG. **2**, or alternatively, to local gateway **210** as previously described.

Having illustrated and described the operation of the various combinations of RF transmitters and transceivers consistent with the present invention, reference is now made to FIG. **4**, which is a block diagram illustrating certain principal components and the operation of a local gateway **210** of a control system **100** (see FIG. **2**) constructed in accordance with the present invention. The primary physical components that may be provided within local gateway **210** are a transceiver **420**, a CPU **422**, a memory **424**, a network card **426**, a DSL modem **428**, an ISDN card **430**, as well as other components not illustrated in the FIG. **4** that would enable a TCP/IP connection to WAN **230**. The transceiver **420** is configured to receive incoming signals consistently formatted in the convention previously described. Local gateway **210** may be configured such that memory **424** includes look up table **425** to assist in identifying the remote and intermediate transceivers used in generating and transmitting the received data transmission. Program code within the memory **424** may also be provided and configured for controlling the operation of a CPU **422** to carry out the various functions that are orchestrated and/or controlled by local gateway **210**. For example, memory **424** may include program code for controlling the operation of the CPU **422** to evaluate an incoming data packet to determine what action needs to be taken. In this regard, look up tables **425** may also be stored within memory **424** to assist in this process. Furthermore, memory **424** may be configured with program code configured to identify a remote transceiver **427** or identify an intermediate transceiver **429**. Function codes, transmitter and or transceiver identification numbers, may all be stored with associated information within look up tables **425**.

Thus, one look up table may be provided to associate transceiver identification numbers with a particular user. Another look up table may be used to associate function codes with the interpretation thereof. For example, a unique code may be associated by a look up table to identify functions such as test, temperature, smoke alarm active, security system breach, etc. In connection with the lookup tables **425**, memory **424** may also include a plurality of code segments that are executed by CPU **422**, and which largely control the operation of the computer. For example, a first data packet segment **330** may be provided to access a first lookup table to determine the identity of the transceiver which transmitted the received message. A second code segment may be provided to access a second lookup table to determine the proximate location of the message generating transceiver, by identifying the transceiver that relayed the message. A third code segment may be provided to identify the content of the message transmitted. Namely, is it a fire alarm, a security alarm, an emergency request by a person, a temperature control setting, etc. Consistent with the invention, additional, fewer, or different code segments may be provided to carryout different functional operations and data signal transfers throughout the transceiver network.

The local gateway **210** may also include one or more mechanisms through which to communicate with remote systems. For example, the gateway may include a network card **426**, which would allow the gateway **210** to communicate across a local area network to a network server, which in turn may contain a backup gateway to WAN **230**. Alternatively, local gateway **210** may contain a DSL modem **428**, which may be configured to provide a direct dial link to a remote system, by way of the PSTN. Alternatively, local gateway **210** may include an ISDN card **430** configured to communicate via an ISDN connection with a remote system. Other communication gateways may be provided as well to serve as primary and or backup links to WAN **230** or to local area networks that might serve to permit local monitoring of gateway health and data packet control.

Reference is now made to FIG. **5**, which is a diagram illustrating WAN connectivity in a system constructed in accordance with the invention. In this regard, local gateway **210** is configured to transmit control signals and receive data signals using the open data packet protocol as previously described. Local gateway **210** is preferably interconnected permanently on WAN **230** and configured to translate received data signals for WAN transfer via TCP/IP. A server **530** configured with web applications and client specific applications as required is connected to WAN **230** via router **510** and further protected and buffered by firewall **520**. Consistent with the present invention, server **530** is assisted in its task of storing and making available client specific data by database server **540**. A workstation **560** configured with a Web browser is connected to WAN **230** at client premises by any suitable means known by those of skill in the art. Alternatively, clients may access WAN **230** via remote laptop **550** or other devices configured with a compatible Web browser. In this way, server **530** may provide client specific data upon demand.

Having described the control system of FIG. **2**, reference is now made to FIG. **6** which illustrates a specific monitoring embodiment consistent with application of the invention. More specifically, FIG. **6** illustrates a remote utility meter monitoring system **600**. Remote utility meter subsystem **610** consists of utility meter **613** and an appropriately integrated sensor **612** wherein the current utility meter operational status and current utility meter usage total is transmitted via functional codes along with a transceiver identification code in a manner previously described by transmitter **614** to stand-alone transceiver **221**. Stand-alone transceiver **221** further processes and transmits the encoded data to local gateway **210** which translates the data packet information into TCP/IP format for transfer across WAN **230** to server **260**. Server **260** collects and formats the utility meter information for viewing and or retrieval upon client demand in a manner previously described.

Having described a specific client application consistent with the present invention wherein the remote transmitter is permanently integrated with a stationary data input point (a utility meter), reference is now made to FIG. **7** which more fully illustrates the flexibility of the invention. More specifically, FIG. **7** illustrates a remote automotive diagnostics monitoring system **700**. Remote automotive diagnostics interface unit **710** consists of sensor **712** integrated with the vehicle diagnostics data bus **711**, and transmitter **714** wherein contents of the vehicle diagnostics can be downloaded upon a control signal to sensor **712** from a remote location serviced by local gateway **210**. In this manner, a vehicle in need of service but still capable of accessing the vehicle diagnostics codes can be remotely diagnosed by uploading the information through remote automotive diagnostics monitoring sys-

tem 700 and accessing a custom report created by server 260 in a manner previously described. In this regard, server 260 could be configured to perform any of a number of levels of diagnostics and provide service manual instructions, figures, and local authorized service contact information via WAN 230 on a fee basis or per a predetermined level of service plan.

Having described a monitoring system consistent with the present invention wherein the control signal initiates the monitoring process, reference is now made to FIG. 8. FIG. 8 illustrates a client specific control system consistent with both monitoring and control functions of the invention. More specifically, FIG. 8 illustrates a remote irrigation control system 800. For simplicity, controlled area 810 is represented by a single rain gauge 813 and a single related spray head 817. It is easy to see that such a system could be modified and expanded to monitor and control any of a number of irrigation systems integrated with the present invention.

Controlled area 810 is configured with a rain gauge 813 integrated with sensor 811 wherein rainfall and applied water to the adjacent area is transmitted via functional codes by transmitter 812 along with a related transceiver identification code in a manner previously described to stand-alone transceiver 221. Stand-alone transceiver 221 further processes and transmits the encoded data to local gateway 210 which translates the data packet information into TCP/IP format for transfer across WAN 230 to server 260. Server 260 collects and formats the rain gauge data for viewing or retrieval upon client demand in a manner previously described. Additionally, server 260 may be configured to communicate data to operate spray head 817 by opening water supply valve 816 integrated with actuator 814 by sending a control signal to transceiver 815, per a client directed water application control schedule. Alternatively, a customer workstation 250 could periodically download and review the rain gauge data and could initiate an automatic control signal appropriate with the customer's watering requirements. In yet another embodiment, a customer technician could initiate a control signal upon review of the rain gauge information and making the determination that more water is required.

Reference is now made to FIG. 9 which illustrates the operation of an automated parking control system 900 consistent with the present invention. Automated parking facility 910 consists of a controlled access area with ingress gate 920 and egress gate 930. Both gates 920 and 930 are further configured with a position sensor, an actuator, and transceiver illustrated as ingress assembly 922 and egress assembly 932, respectively. Parking spaces 940 may be configured with vehicle sensors. Sensor-transceiver assembly 932 may be configured to transmit a function code associated with the condition of parking spaces 1, 2, 3, and 4. It will be appreciated by those skilled in the art that the single row of four appropriately configured parking spaces illustrated can be expanded by adding parking spaces configured with vehicle sensors integrated with control system 900 via multiple sensor-transceiver assemblies. Automated parking control system 900 collects data signals from each sensor-transceiver assembly 932, integrated in the system, and compiles a master schedule consisting of scheduled use for each parking space in the automated parking facility. In this manner, a customer with access to WAN 230 and server 530 may make a reservation and or check the availability of parking spaces at the automated parking facility from her home or office (or through any Internet portal). For example, a customer that will be out of town on business for 2 days next week, may access the automated parking control system server 530 by using a Web browser to view parking availability for the target travel dates. The customer may reserve the parking slot by providing a personal transmitter identification code (or other identification code) that the customer intends to use to access and exit the facility the following week. When the customer arrives at the ingress gate 920, the customer may enter the automated parking facility 910 by depressing a button on her personal portable transmitter (see FIG. 3A). Ingress assembly 922 receives and forwards the customer's transmitted identification code to server 530 via gateway 210 and WAN 230 in a manner previously described. Server 530 confirms the customer's reservation, alternatively checks space availability to determine if access should be granted. In addition, server 530 may be further programmed to determine if the particular customer has an established account with the facility owner or whether a credit card payment transaction is in order. Automatic parking facility control system 900 would record the actual use of the reserved parking space for storage on database server 540. Server 530 could retrieve the stored usage information on a periodic basis from database server 540 and generate appropriate bills for each customer.

Alternatively, the customer could reserve the slot by providing billing information via WAN 230 and ingress gate 920 could be further configured with a credit card reader and an alphanumeric keypad interface. Both the credit card reader and the alphanumeric keypad interface could be interconnected to the automated parking facility control system 900 by their own appropriately configured transceiver. Either or both the credit card reader and the alphanumeric keypad interface could be used to identify customers with reservations.

The operator of parking facility control system 900, can expand both the level of security of the parking facility and the services provided by adding networked peripherals in a manner previously described and upgrading the software applications on server 530. For example, by adding automated ingress and egress gates configured to allow the entry and exit of parking facility customers and authorized personnel and configuring the egress gate 930 for vehicles such that only identified customers may exit with a vehicle, both customers and their vehicles are protected from thieves.

A further example of expanding the services offered by automated parking facility control system 900 might consist of offering a schedule of vehicle services that could be scheduled and performed on the vehicles of long-term parking customers. By adding the appropriate interface to server 530, parking facility customers could be prompted when making their reservation with a list of potential vehicle services that could be scheduled and performed by vehicle service technicians during the duration of the customer's business trip. A customer interested in having her automobile's oil changed and tires rotated would authorize and schedule the desired services when arranging her parking reservation. Upon leaving the parking facility at the start of her business trip, the customer could leave her vehicle valet key in an appropriately identified lock box. After her trip is complete, the customer returns to the lot. She gains access to the lot by any of the aforementioned methods and retrieves her valet key by similarly identifying herself as the vehicle owner.

Having illustrated specific applications using the present invention in FIGS. 6 through 9, reference is now made to FIG. 10 which illustrates a system 1000 that monitors and controls remote data points associated with a plurality of systems. In this embodiment, server 530 may be configured with monitor/control remote services 1010 application-specific software. For example, the controlled area 810 of the irrigation control system shown in FIG. 8, the remote utility meter subsystem 610 of FIG. 6, and the automated parking facility 910 of FIG. 9 may be monitored and remotely controlled (where required)

by server **530**. In a manner previously described herein, server **530** collects and processes data information transferred and sent over WAN **230** by local gateways coupled via RF links to transceivers and transmitters associated with systems **1020**, **1030**, and **1040**. Alternatively, server **530** initiates control signals that may be sent via the gateways to the appropriate transceivers and transmitters as required. For ease of illustration and description, FIG. **10** shows each of the systems serviced by server **530** requiring its own dedicated local gateway. It will be appreciated by those skilled in the art that small-scale systems jointly located within a geographic area served by an array of transceivers and a gateway may be configured to share the transceiver and gateway infrastructure of a previously installed local system.

Having described the physical layer of a system consistent with the present invention, reference is now made to FIG. **11** which describes the data structure of messages sent and received using the invention. In this regard, the standard message consists of: to address; from address; packet number; maximum packet number, packet length; command; data; packet check sum (high byte); and packet check sum (low byte). The "to address" or message destination consists from 1 to 6 bytes. The "from address" or message source device is coded in a full 6 byte designator. Bytes **11** through **13** are used by the system to concatenate messages of packet lengths greater than 256 bytes. Byte **14** is a command byte. Byte **14** works in conjunction with bytes **15** through **30** to communicate information as required by system specific commands. Bytes **31** and **32** are packet check sum bytes. The packet check sum bytes are used by the system to indicate when system messages are received with errors. It is significant to note that bytes **31** and **32** may be shifted in the message to replace bytes **15** and **16** for commands that require only one byte. The order of appearance of specific information within the message protocol of FIG. **11** remains fixed although the byte position number in individual message transmissions may vary due to scalability of the "to address," the command byte, and scalability of the data frame.

Having described the general message structure of a message of the present invention, reference is directed to FIG. **12** which illustrates three sample messages. The first message illustrates the broadcast of an emergency message "FF" from a central server with an address "0012345678" to a personal transceiver with an address of "FF."

The second message illustrated reveals how the first message might be sent to a transceiver that functions as a repeater. In this manner, emergency message "FF" from a central server with address "0012345678" is first sent to transceiver "F0." The second message, further contains additional command data "A000123456" that may be used by the system to identify further transceivers to send the signal through on the way to the destination device.

The third message illustrated on FIG. **12** reveals how the message protocol of the present invention may be used to "ping" a remote transceiver in order to determine transceiver health. In this manner, source unit "E112345678" originates a ping request by sending command "08" to a transceiver identified as "A012345678." The response to the ping request can be as simple as reversing the "to address" and the "from address" of the command, such that, a healthy transceiver will send a ping message back to the originating device. The system of the present invention may be configured to expect a return ping within a specific time period. Operators of the present invention could use the delay between the ping request and the ping response to model system loads and to determine if specific system parameters might be adequately monitored and controlled with the expected feedback transmission delay of the system.

Having described the message structure of a message of the present invention, reference is directed to FIG. **13** which illustrates the integration of the system of the present invention with the control system of FIG. **1**. Having previously illustrated several variations consistent with the principles of the present invention, it will be appreciated by those skilled in the art that multiple variations of the present invention may be integrated with existing control systems. In this regard, an existing control system with local controller **110** and a plurality of sensor actuators **115** (one shown for simplicity of illustration) are in communication with central controller **130** via PSTN **120** as previously described. In a manner well known in the art of control systems, local controller **110** transmits appropriate status information via PSTN **120** to central controller **130**.

Control systems consistent with the design of FIG. **1**, as further illustrated in FIG. **13**, require the routing of electrical conductors to each sensor and actuator as the application requires. It will be appreciated by those skilled in the art that the system of the present invention can take advantage of the infrastructure of an existing system by inserting data translator **140** such that system data is sent to both the central controller **130** in the old configuration, as well as, the data translator **140**. Data translator **140** serves to convert system data to function codes as previously described. Once data translator **140** successfully converts the system data stream to the message protocol of the present invention, transceiver **815** further converts the system data stream to a RF signal.

As previously described in connection with FIG. **2**, stand-alone transceiver **221** receives and repeats the RF data transmission received from transceiver **815**. Local gateway **210** receives the RF data transmission repeated by stand-alone transceiver **221** and converts the RF data transmission into TCP/IP for further transmission across WAN **230** to server **260**. In this regard, server **260** may further manage the data for internal storage or alternatively storage in database **270**. Customers with WAN **230** access may access the system data from workstation **250** or laptop computer **240**.

Having described integration of the system of the present invention with the control system of FIG. **1** in FIG. **13**, reference is now directed to FIG. **14** which illustrates integration of the system of the present invention with mobile inventory units. In this regard, system **1060** consists of the system of the present invention as previously illustrated and described in FIGS. **1** and **13**. Having previously illustrated several variations consistent with the principles of the present invention, it will be appreciated by those skilled in the art that multiple variations of the present invention may be integrated with mobile inventory units **1070**. In this regard, sensor/actuator **115** integrated with transceiver **815** in sensor-transceiver assembly **1065** is further integrated with any of a number of mobile inventory units **1070** (one sensor-transceiver unit **1065** shown for simplicity of illustration). It will be appreciated by those skilled in the art that as long as a mobile inventory unit **1070**, herein represented by a package, ship, airplane, train, and a taxi are within the radio-frequency transmission and receiving range of stand-alone transceiver **221**, the system of the present invention may be used to monitor, store and report information of and relating to mobile inventory unit **1070**.

It will be further appreciated by those skilled in the art that the system of the present invention may be used to transfer information to adequately equipped mobile inventory units **1070**. In this regard, shipping companies may use the present

invention to update a database containing location and status information for each mobile inventory unit 1070 in the company fleet. Shipping companies may also transfer informative messages or other information using the system of the present invention.

In one embodiment, the present invention may be used to store, retrieve, and update maintenance information related to individual mobile inventory units. For example, federally registered airplanes must keep a maintenance log with the craft detailing all inspections, maintenance, and repairs. The system of the present invention could be used by fixed base operators (FBOs) who perform inspections and maintenance on aircraft to retrieve and update the aircraft maintenance log. In this way, FBOs located throughout the world will be able to retrieve and update an electronic version of the maintenance history of an aircraft. In addition, a properly configured system could also contain maintenance directives and other service bulletins related to the particular aircraft.

In yet another embodiment, a properly integrated sensor/actuator 115 with transceiver 815 may be used to monitor mobile inventory unit system parameters. For example, an airplane could be configured to monitor and report engine run time, time elapsed since the last recorded inspection of a particular type, and related system information. It will be appreciated by those skilled in the art that the system of the present invention may be integrated with remote units other than those shown. The ship, package, airplane, train, and taxi shown in FIG. 14 are for example only and not meant to limit the scope of the present invention.

It will be appreciated that the foregoing description has illustrated certain fundamental concepts of the invention, but that other additions and/or modifications may be made consistent with the inventive concepts. For example, the one-way transmitters illustrated in FIG. 3A and implemented in a control system as illustrated in FIG. 6 may be adapted to monitor the current status of water, gas, and other utility meters. One-way transmitters might further be used to monitor and report actual operational hours on rental equipment or any other apparatus that must be serviced or monitored on an actual run-time schedule.

The two-way transceivers of the current invention, may be adapted to monitor and apply control signals in an unlimited number of applications. By way of example only, two-way transceivers of the current invention can be adapted for use with pay type publicly located telephones, cable television set converter boxes, as well as, for use with a host of residential appliances and devices to enable a remote controllable home automation and security system.

In a geographic area appropriately networked with permanently located transceivers consistent with the invention, personal transmitters consistent with the invention can be used to monitor and control personnel access and egress from specific rooms or portions thereof within a controlled facility. Personal transmitters can further be configured to transfer personal information to public emergency response personnel, personal billing information to vending machines, or to monitor individuals within an assisted living community.

Two-way transceivers consistent with the present invention can be integrated to monitor and control a host of industrial and business applications as well. By way of example only, building automation systems, fire control systems, alarm systems, industrial trash compactors, and building elevators can be monitored and controlled with devices consistent with the present invention. In addition, courier drop boxes, time clock systems, automated teller machines, self-service copy machines, and other self-service devices can be monitored and controlled as appropriate. By way of further example, a number of environment variables that require monitoring can be integrated with the system of the present invention to permit remote monitoring and control. For instance, light levels in the area adjacent to automated teller machines must meet minimum federal standards, the water volume transferred by water treatment plant pumps, smokestack emissions from a coal burning power plant or a coke fueled steel plant oven may also be remotely monitored.

The two-way transceivers of the present invention may be further integrated with a voice-band transmitter and receiver. As a result, when a person presses, for example, the emergency button on his/her transmitter, medical personnel, staff members, or others may respond by communicating via two-way radio with the party in distress. In this regard, each transmitter may be equipped with a microphone and a speaker that would allow the person to communication information such as their present emergency situation, their specific location, etc.

The foregoing description has been presented for purposes of illustration and description. It is not intended to be exhaustive or to limit the invention to the precise forms disclosed. Obvious modifications or variations are possible in light of the above teachings. For example, it should be appreciated that, in some implementations, the transceiver identification number is not necessary to identify the location of the transmitter. Indeed, in implementations where the transmitter is permanently integrated into an alarm sensor other stationary device within a system, then the control system server and or local gateway could be configured to identify the transmitter location by the transmitter identification number alone. In will be appreciated that, in embodiments that do not utilize repeating transceivers, the transmitters will be configured to transmit at a higher RF power level, in order to effectively communicate with the control system local gateway.

The embodiment or embodiments discussed were chosen and described illustrate the principles of the invention and its practical application to enable one of ordinary skill in the art to utilize the invention in various embodiments and with various modifications as are suited to the particular use contemplated. All such modifications and variations are within the scope of the invention as determined by the appended claims when interpreted in accordance with the breadth to which they are fairly and legally entitled.

We claim:

1. A system for remote data collection, assembly, storage, event detection and reporting and control, comprising:

a computer configured to execute at least one computer program that formats and stores select information for retrieval upon demand from a remotely located device, said computer integrated with a wide area network (WAN);

a plurality of transceivers dispersed geographically at defined locations, each transceiver electrically interfaced with a sensor and configured to receive select information and identification information transmitted from another nearby wireless transceiver electrically interfaced with a sensor in a predetermined signal type and further configured to wirelessly retransmit in the predetermined signal type the select information, the identification information associated with the nearby wireless transceiver, and transceiver identification information associated with the transceiver making retransmission;

at least one gateway connected to the wide area network configured to receive and translate the select information, the identification information associated with the nearby wireless transceiver, and transceiver identifica-

tion information associated with one or more retransmitting transceivers, said gateway further configured to further transmit the translated information to the computer over the WAN and wherein at least one of said plurality of transceivers is also electrically interfaced with an actuator to control an actuated device.

2. The system of claim 1, wherein the control of the actuation device by the actuator corresponds to a sensed condition detected by the sensor electrically interfaced to the at least one of said plurality of transceivers also electrically interfaced with the actuator.

3. The system of claim 1, further comprising: a keypad electrically interfaced to one or more of said plurality of transceivers configured to receive user input.

4. The system of claim 1, further comprising: a keypad electrically interfaced to one or more of said plurality of transceivers configured to receive user input, wherein said user input corresponds to instructions for the actuator to control the actuation device.

5. The system of claim 1, wherein a command to control the actuated device by the actuator may be received locally at the at least one of said plurality of transceivers also electrically interfaced with the actuator or from a wireless transmission from another of the plurality of transceivers dispersed geographically at defined locations.

6. The system of claim 1, wherein the actuated device is a home appliance.

7. The system of claim 6, wherein the home appliance is a home temperature control system.

8. A method for collecting information, providing data services, and controlling remote systems, comprising:

adaptively configuring at least one transmitter electrically interfaced with a sensor and an actuator wherein the transmitter generates an information signal consisting of a transmitter identification code and an information field, wherein the information signal is received by another nearby transmitter electrically interfaced with one or both of a sensor and an actuator and repeated in the same signal type as received to additional transmitters each electrically interfaced with one or both of a sensor and an actuator for communicating the information signal to a gateway, the gateway providing access to a WAN;

translating the information signal within the gateway into a WAN compatible data transfer protocol;

transferring the information signal via the WAN to a computer wherein the computer is configured to manipulate and store data provided in the information signal; and granting client access to the computer.

9. The method of claim 8, further comprising receiving a communication wirelessly at the transmitter electrically interfaced with a sensor and an actuator from another nearby transmitter an instruction to control the actuator.

10. The method of claim 9, wherein the control of the actuator is either from a state of on to off or from a state of off to on.

11. The method of claim 9, wherein the control of the actuator causes the actuator to operate at a changed level of operation.

12. The method of claim 8, further comprising receiving user input on a keypad electrically interfaced with the transmitter electrically interfaced with a sensor and an actuator, wherein receipt of user input on the keypad causes actuation of the actuator.

13. In a system comprising a plurality of wireless devices configured for remote wireless communication and comprising a device for monitoring and controlling remote devices, the device comprising:

a transceiver having a unique identification code and being electrically interfaced with a sensor, the transceiver being configured to receive select information and identification information transmitted from another wireless transceiver in a predetermined signal type;

the transceiver being further configured to wirelessly retransmit in the predetermined signal type the select information, the identification information associated with the nearby wireless transceiver, and transceiver identification information associated with the transceiver making retransmission; and

a data controller operatively coupled to the transceiver and the sensor, the data controller configured to control the transceiver and receive data from the sensor, the data controller configured to format a data packet for transmission via the transceiver, the data packet comprising data representative of data sensed with the sensor.

14. The device of claim 13, wherein the data controller is configured to receive data packets comprising control signals and in response to the control signals provide a control signal to an actuator for implementation of a command.

15. The device of claim 13, wherein the device is at least one of a thermostat, sized and shaped to be worn/carried by a person, disposed within an automobile/vehicle, a utility meter, a rain gauge, a mobile inventory unit and an irrigation control system.

16. The device of claim 13, wherein the data controller is configured to receive data packets comprising a function code, and in response to the function code, implement a function.

17. The device of claim 13, wherein the data controller is configured to format data packets for transmission via the transceiver, the data packets comprising a function code corresponding to sensed data and the unique identification code that identifies the transceiver.

18. The device of claim 13, further comprising a memory to store one or more function codes corresponding to the device, the function codes corresponding to a number of functions the data controller can implement.

19. The device of claim 13, further comprising an actuator configured to receive command data from the controller and in response implement the command.

20. In a wireless system that includes remote devices for monitoring and controlling remote devices having wireless communication devices, the system comprising a wireless enabled thermostat device, the wireless enabled thermostat device comprising:

a transceiver having a unique identification code and being interfaced with a sensor, the transceiver being configured to receive select information and identification information transmitted from another wireless transceiver in a predetermined signal type;

the transceiver being further configured to wirelessly retransmit in the predetermined signal type the select information, the identification information associated with the nearby wireless transceiver, and transceiver identification information associated with the transceiver making retransmission; and

a controller operatively coupled to the transceiver and the sensor, the controller configured to control transceiver operations and receive data from the sensor, the controller configured to format data packets for transmission

via the transceiver, the data packet comprising data representative of data sensed with the sensor.

21. The wireless enabled thermostat device of claim **20**, further comprising an actuator, operatively coupled to the controller, the actuator configured to receive a command from the controller and implement the command thereby adjusting a condition associated with temperature.

22. The wireless enabled thermostat device of claim **20**, wherein the unique identification code of the transceiver is electrically programmable.

23. The wireless enabled thermostat device of claim **20**, wherein the thermostat device is coupled to a user device via a network and wherein the user device provides user control signals responsive to user input, and wherein the transceiver receives the user control signals and the controller implements control of temperature conditions based on the user control signals.

24. The wireless enabled thermostat device of claim **20**, further comprising a memory to store one or more function codes corresponding to the thermostat device, the function codes corresponding to a number of functions the data controller can implement.

25. The wireless enabled thermostat device of claim **20**, further comprising an actuator configured to receive command data from the controller and in response implement the command.

26. A wireless communication device capable of communicating with another wireless communication device in a wireless network, the wireless communication device comprising:

a transceiver having a unique identification code and being interfaced with a sensor, the transceiver being configured to receive information and identification information transmitted from another wireless transceiver in a predetermined signal type;

a controller operatively coupled to the transceiver and the sensor, the controller configured to control transceiver operations and receive data from the sensor, the controller configured to format data packets for transmission via the transceiver with at least some data packets comprising data representative of data sensed with the sensor; and

wherein the controller is configured to format some data packets by concatenating received data packets with data packets formatted by the controller enabling the controller to prepare data for transmission that includes repeated data and sensed data.

27. The wireless communication device of claim **26**, wherein the controller selects a function code for inclusion into a data packet based on data sensed by the sensor.

28. The wireless communication device of claim **26**, wherein the transceiver has a plurality of distinct predetermined function codes for inclusion into a data packet, and wherein the predetermined function codes are unique to the transceiver.

29. The wireless communication device of claim **26**, wherein the transceiver has a plurality of distinct predetermined function codes that are different from function codes associated with another wireless communication device.

30. The wire less communication device of claim **26**, wherein the controller is configured to receive control signals from a data packet and based on the control signals send instructions to an actuator to implement a command.

31. A wireless communication system including wireless communication devices capable of wireless communication, the wireless communication system comprising:

at least one wireless communication device comprising a transceiver, the transceiver having a unique identification code and being interfaced with a sensor, the transceiver being configured to receive select information and identification information transmitted from another wireless transceiver in a predetermined signal type;

a controller operatively coupled to the transceiver and the sensor, the controller configured to control transceiver operations and receive data from the sensor, the controller configured to format data packets for transmission via the transceiver with at least some data packets comprising data representative of data sensed with the sensor; and

wherein the controller is configured to receive control signals from a data packet and based on the control signals send instructions to an actuator to implement a command.

32. The wireless communication system of claim **31**, further comprising at least one gateway connected to a WAN configured to receive and translate the select information, the identification information associated with the nearby wireless transceiver, and transceiver identification information associated with one or more retransmitting transceivers, said gateway further configured to further transmit the translated information to a computing device over the WAN.

33. The wireless communication system of claim **31**, further comprising a computing device configured to receive user input and based on user input, the computing device formatting control signals, and wherein the controller is configured to receive the control signals via wireless transmission and take action based on the control signals.

34. The wireless communication system of claim **31**, wherein the controller is configured to provide one or more function codes in the data packet in response to data sensed by the sensor.

35. The wireless communication system of claim **31**, wherein the controller comprises a memory containing a plurality of function codes specific to the sensor.

* * * * *

US006105607A

United States Patent [19]

Caise et al.

[11] Patent Number: 6,105,607
[45] Date of Patent: Aug. 22, 2000

[54] **MICROPROCESSOR CONTROLED WATER SHUT-OFF DEVICE**

[76] Inventors: **Robert F. Caise**, 104 Melody La., Naples, Fla. 34114; **Howard G. Worthy, III**, 241 7th Ave. No., Naples, Fla. 34102; **William J. Senkevich**, 601 Nottingham Dr., Naples, Fla. 34109

[21] Appl. No.: **09/349,802**

[22] Filed: **Jul. 9, 1999**

Related U.S. Application Data

[63] Continuation-in-part of application No. 09/097,850, Jun. 15, 1998, abandoned.

[51] **Int. Cl.**[7] **F16K 31/12**
[52] **U.S. Cl.** **137/487.5**; 137/624.12
[58] **Field of Search** .... 137/80, 624.11, 137/624.12, 487.5; 200/31.9 M

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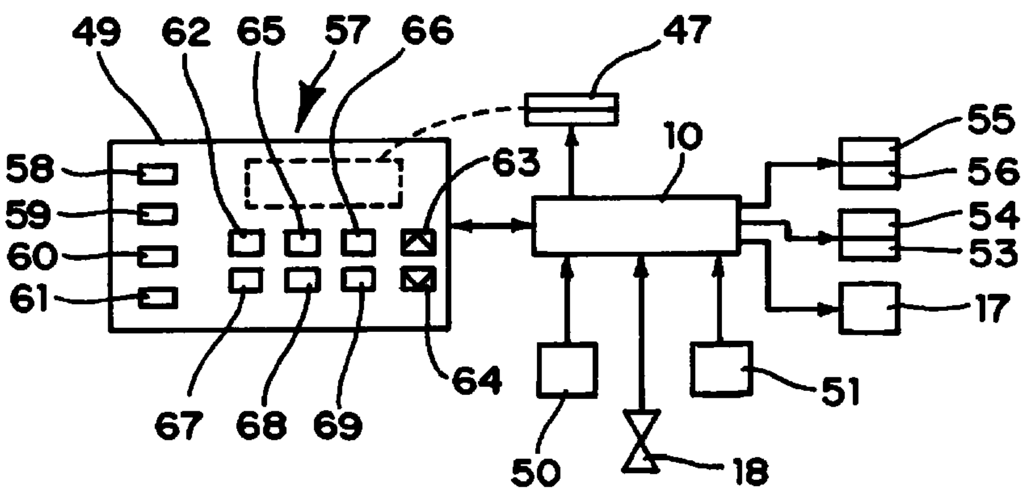
Primary Examiner—Gregory L. Huson
Assistant Examiner—Joanne Y. Kim

[57] **ABSTRACT**

A microprocessor based control system to monitor flow in a potable water system and compare said flow with pre-set programs of time of day and duration of flow, if the pre-set parameters are exceeded the controller will turn off the flow of water.

9 Claims, 6 Drawing Sheets



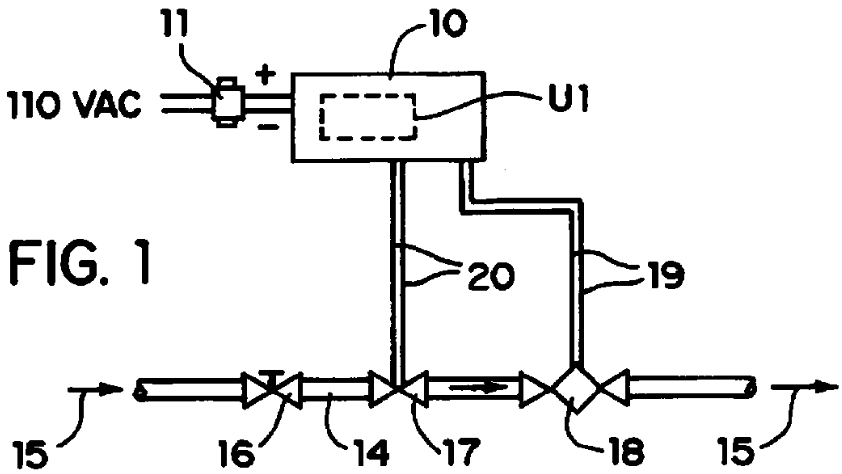

11
10
110 VAC
+
–
U1
20
19
15
16
14
17
18
15

FIG. 1

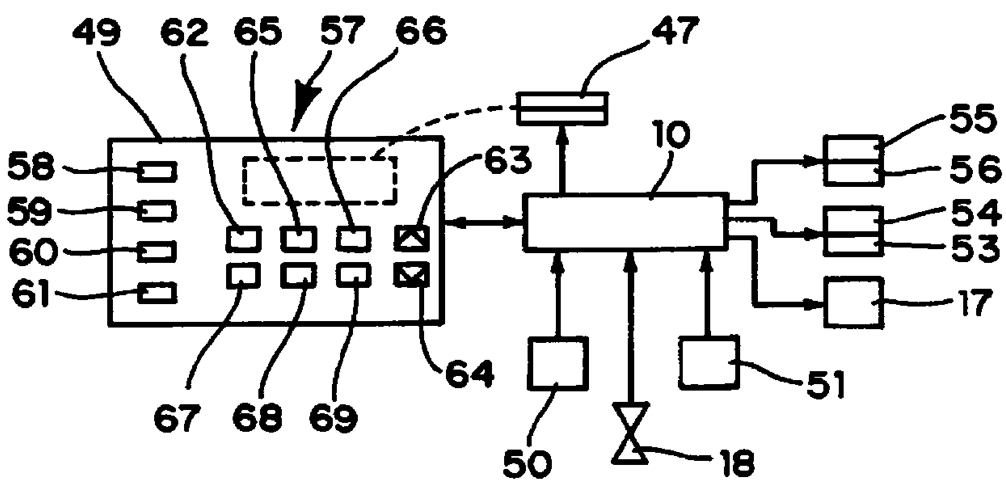

49
62
65
57
66
47
55
56
54
53
17
58
59
60
61
63
10
64
51
67
68
69
50
18

FIG. 2

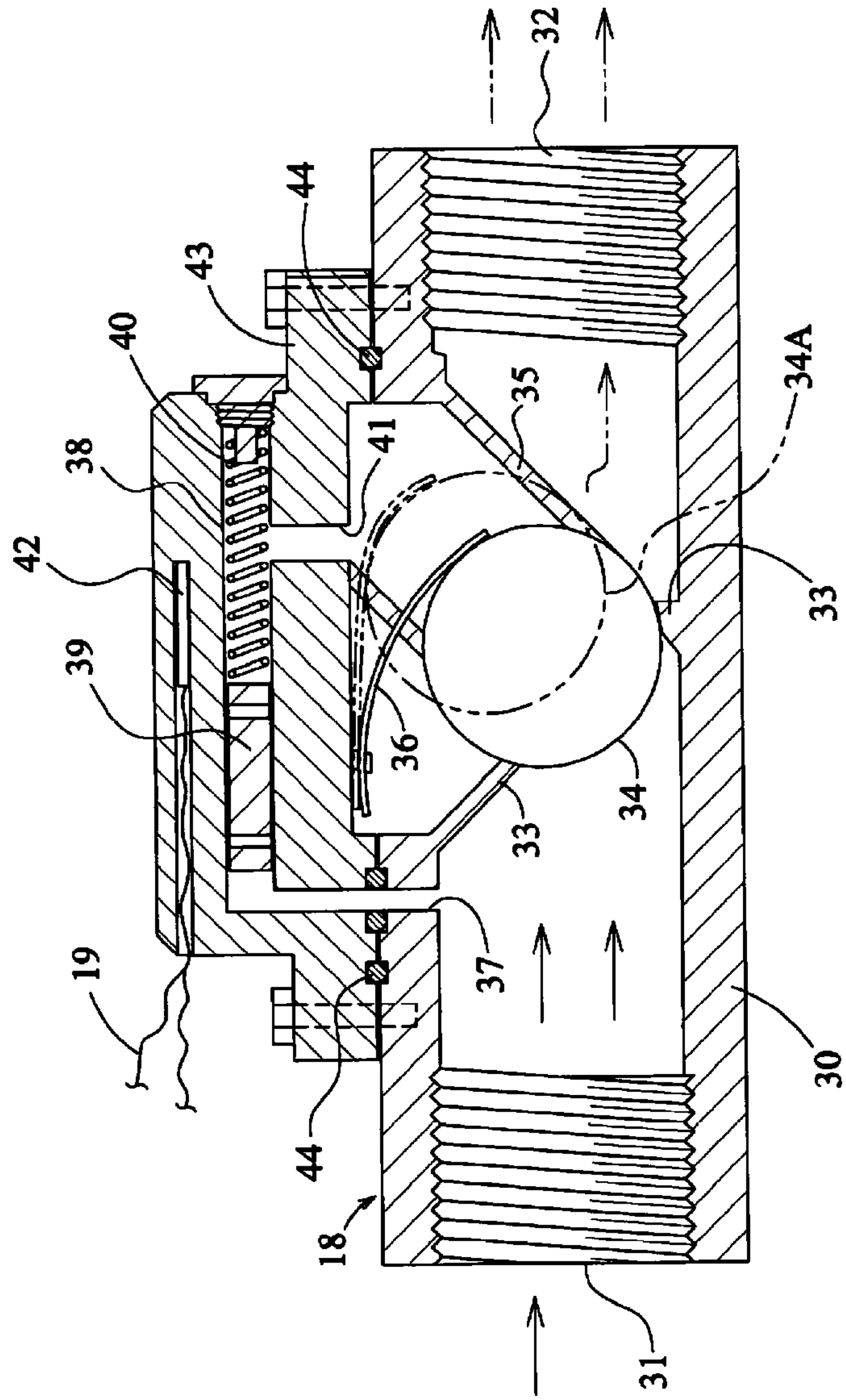


FIG. 3

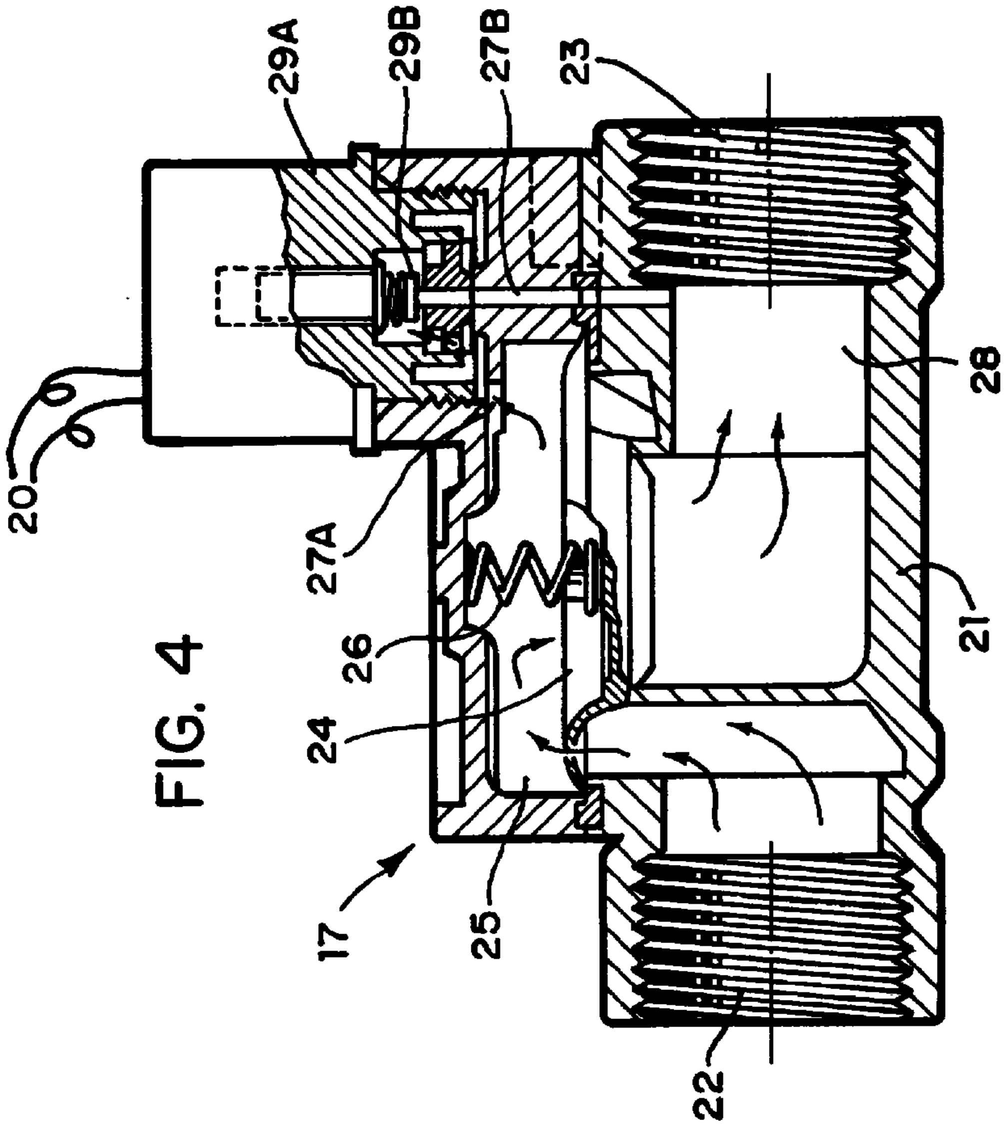


FIG. 4

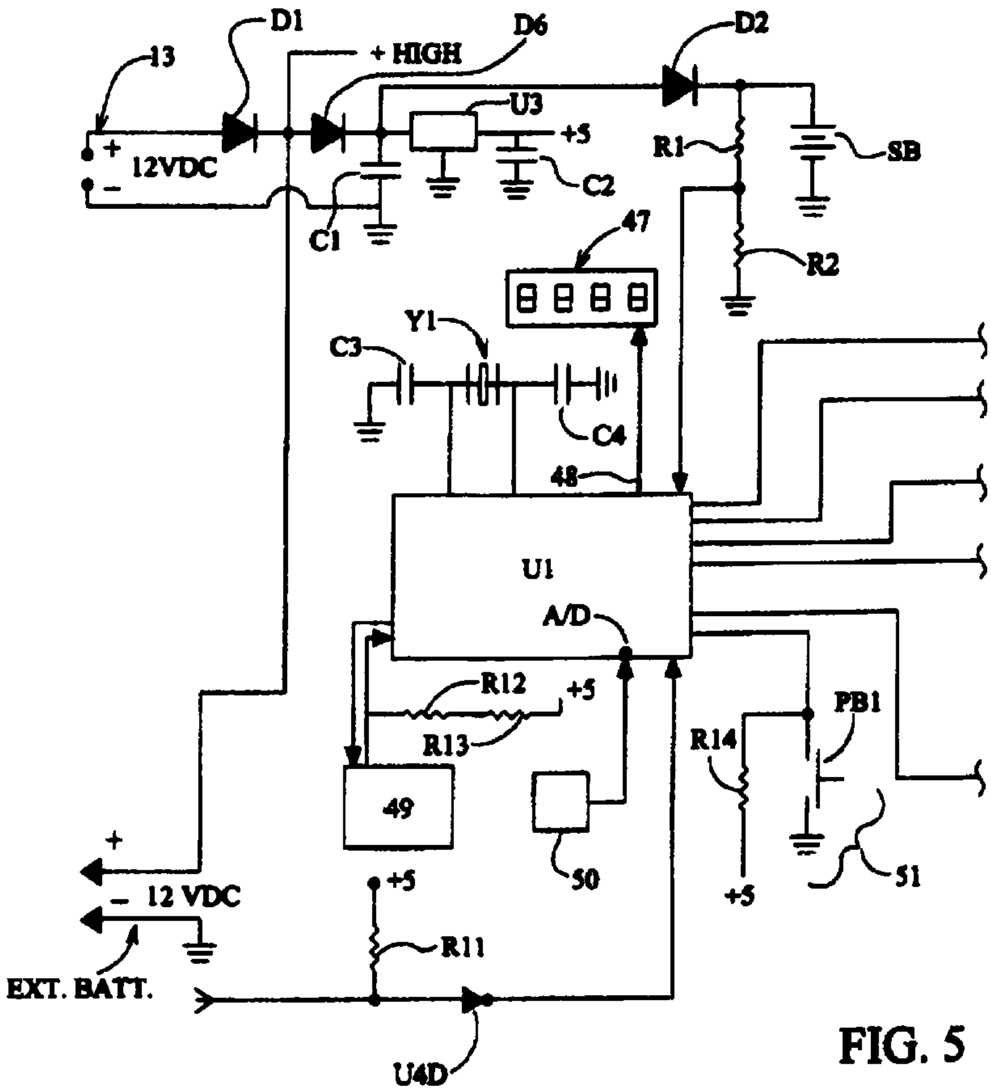

D1
13
+ HIGH
D6
D2
U3
+5
+
12VDC
–
C1
C2
R1
SB
47
R2
Y1
C3
C4
48
U1
A/D
R12
+5
R13
PB1
R14
49
50
51
+
– 12 VDC
EXT. BATT.
+5
R11
+5
U4D

FIG. 5

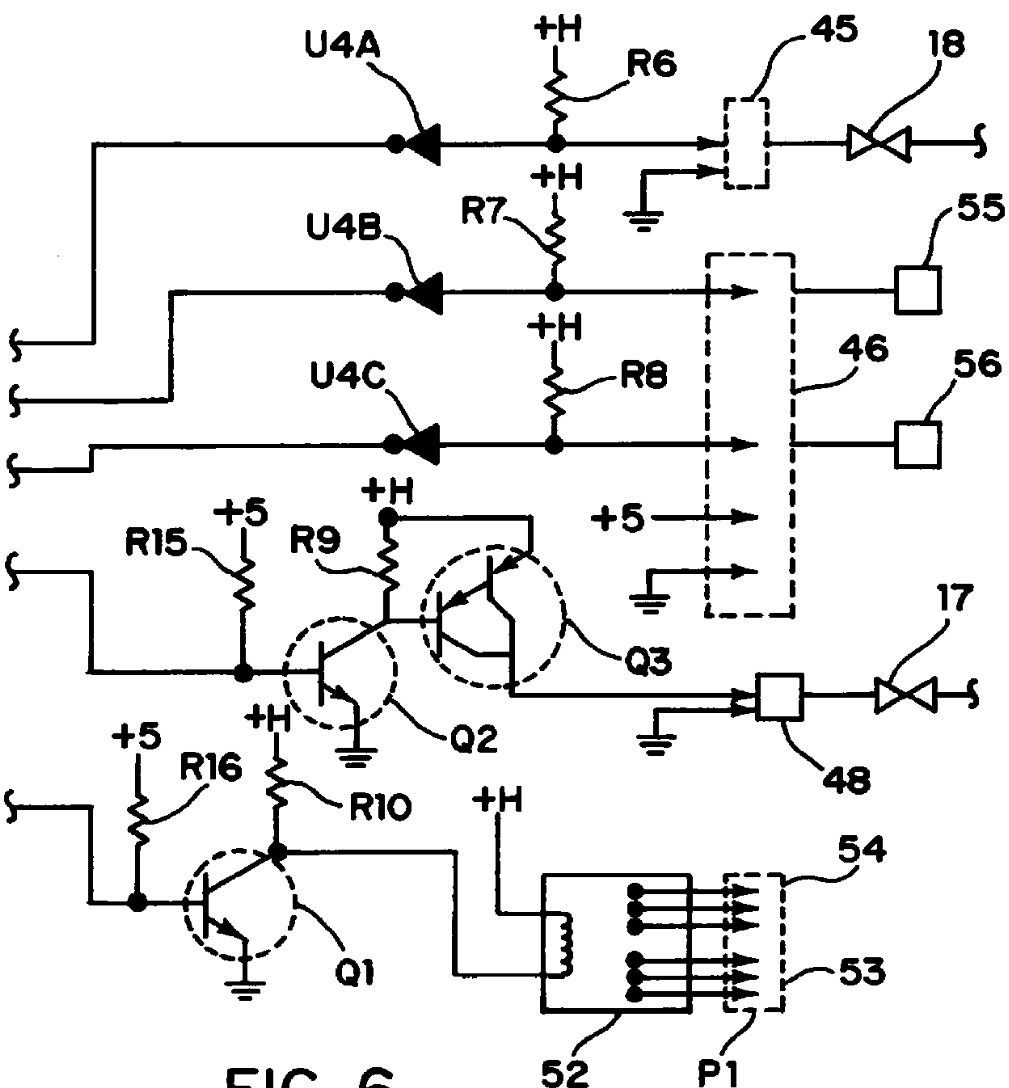

U4A
+H
R6
45
18
+H
R7
U4B
55
+H
46
56
U4C
R8
+H
+5
R15
R9
+5
Q3
17
Q2
+H
48
+5
R16
R10
+H
54
Q1
53
52
P1

FIG. 6

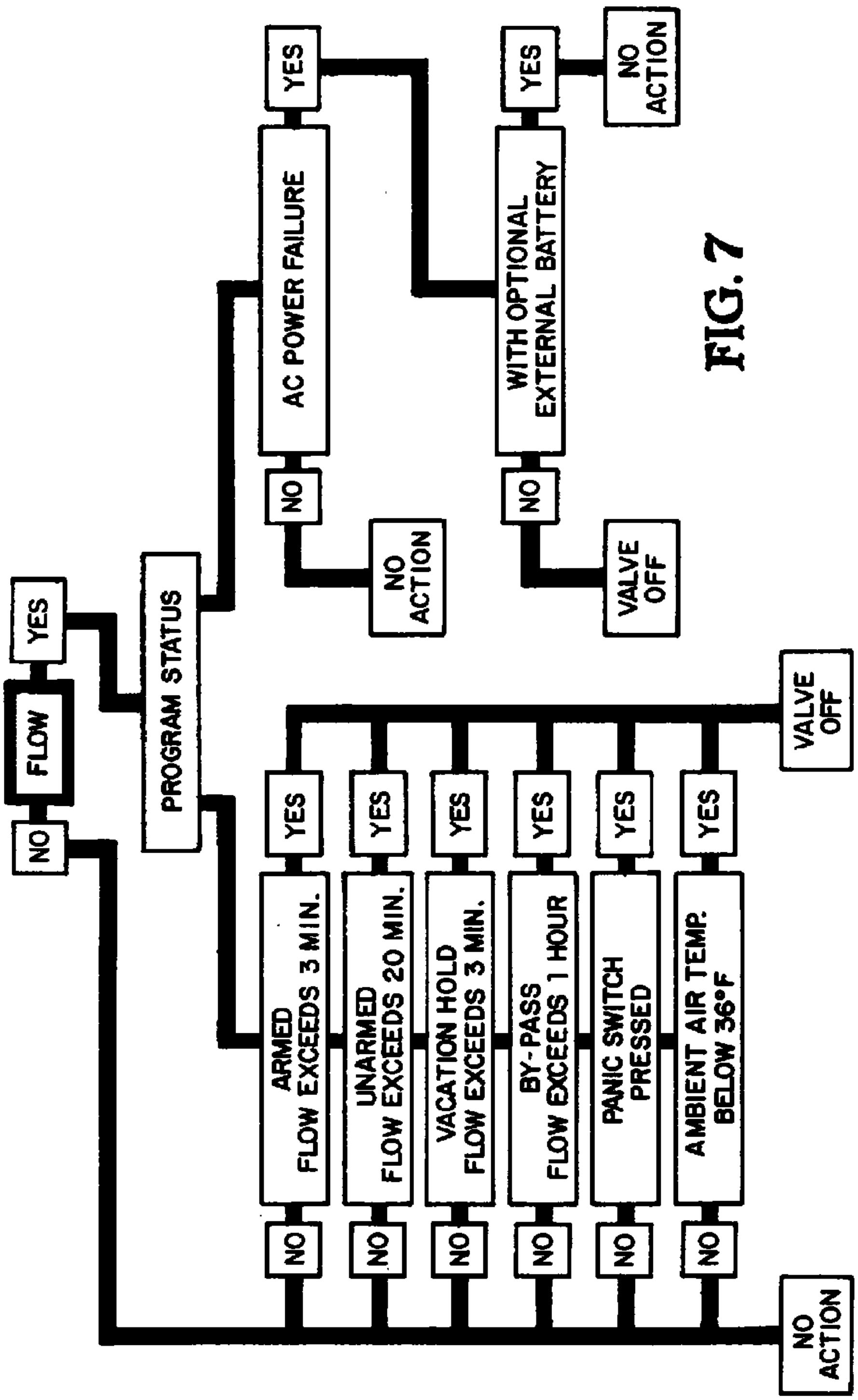

FLOW
NO
YES
PROGRAM STATUS
AC POWER FAILURE
YES
NO
NO ACTION
WITH OPTIONAL EXTERNAL BATTERY
YES
NO ACTION
NO
VALVE OFF
ARMED FLOW EXCEEDS 3 MIN.
UNARMED FLOW EXCEEDS 20 MIN.
VACATION HOLD FLOW EXCEEDS 3 MIN.
BY-PASS FLOW EXCEEDS 1 HOUR
PANIC SWITCH PRESSED
AMBIENT AIR TEMP. BELOW 36°F
YES
NO
VALVE OFF
NO ACTION

FIG. 7

MICROPROCESSOR CONTROLED WATER SHUT-OFF DEVICE

This application is a continuation-in-part of application Ser. No.09/097,850 filed Jun. 15, 1998,now abandoned.

BACKGROUND

1. Field of Invention

This invention relates to a user programmable microprocessor based automatic water shutoff system that will detect unwanted water flow caused by appliance or plumbing failures, and activate a shutoff valve to minimize damage within a structure from unanticipated flow.

2. Background-Prior Art

Prior art devices of this type have relied on a variety of plumbing, valving and detection systems used to minimize water damage within homes and businesses due to appliance or plumbing system failures. While no device can prevent a leak their purpose is to minimize the damage from such leaks.

Typically, a plumbing leak occurs in situations such as burst pipes due to freeze/thaw cycles, water bearing appliance failures, hose ruptures and other leaks that can go undetected for some time if the property is not occupied during that period. While there are many temperature and moisture sensor based hard wired water shutoff systems such as. U.S. Pat. No. 5,090,436 Hoch issued Apr. 4, 1995 uses hard wired temperature and moisture sensors and requires occupant turn on the system manually when protection is desired. Also requires extensive electrical wiring to fully protect a home from water leakage. Our invention is specifically designed for flow detection and control, typical prior art of this is found in U.S. Pat. No. 5,503,175 Ravillious, issued Apr. 2, 1996 which uses a flow sensor that depends on gravity for return of the piston which may not be reliable in certain water conditions, also the flow sensor is restricted in it's mounting to the vertical position and a control circuit that uses mechanical relays and electromechanical delays and requires human operator action when water is desired, a very cumbersome system to use. Whereas the present invention uses a computer based, all solid state components, user programmable control to pre-program water usage 24 hours a day 7 days a week, for a set and forget system. Another U.S. Pat. No. 5,284,884 Cohen, issued Feb.22, 1994 uses a very complicated microphone sensor system to listen for flow at supply and drain lines, also requires a lot of hard wiring, while this system may overcome some of the shortfalls in the Ravillious sensor, it too falls short, in low flow sensitivity, ambient noise and lack of user programmability. Also U.S. Pat. No. 4,518,955 Meyer, issued May 21, 1985 a very complex flow detection system utilizing a microcomputer to monitor time and flow duration, position of fluid drains in the plumbing system, and other information. This system is over-sophisticated and uneconomical for the average household. U.S. Pat. No. 5,056,554 White issued Oct. 15, 1991 Requires two(2) expensive flow meters to allow fill flow and low flow sensitivity. U.S. Pat. No. 5,038,820 Ames issued Aug. 13, 1991 also as with the Hoch patent it must be turned on and off by the occupant also the Ames system is not fail safe in that if a control or battery fails the water valve stays open.

In conclusion the art is replete with various apparatus with claims to control water leaks. Prior art does not teach of an apparatus that is designed to be user defined for a set and forget 24 hour 7 days a week automatic system that is affordable for the average homeowner. It would be highly advantageous therefore, to remedy the foregoing and other deficiencies inherent in the prior art, and issue letters patent for the present invention.

SUMMARY

A microprocessor based water supply control device that is pre-programmed for water usage for 24 hours 7 days a week and uses a flow sensor to detect fluid flow and compare it to a pre-programmed user defined setting, signal indicators and information output displays on a liquid crystal display panel provide current conditions and program information, a key pad provides for input commands to reconfigure the control parameters. A shutoff status determination by the microprocessor in view of a improper flow activates a solenoid shut-off valve that cant be restored until a manual reset signal is inputted by the user.

OBJECTS and ADVANTAGES

Accordingly, several objects and advantages of our invention are:

(a) to provide a reliable system that will minimize property damage caused by pressure water leaks from appliance or plumbing failures.

(b) to provide a system that is flexible in programming.

(c) to provide a system that is fully automatic after initial install.

(d) to provide a system that is easy to reprogram by the user.

(e) to provide a system that is easy to install.

(f) to provide a system that is economical to install.

(g) to provide a system that requires very little maintenance.

(h) to provide a system that is fail safe ,in case of controller or system failure the water valve will close automatically.

(i) to provide a system that user can manually by-pass the water valve in case of failure of other components.

(j) to provide a system that has low flow sensing ability and still allows for full flow.

While this invention will not prevent leaks such as washing machine over flow hose rupture, dishwasher overflow, toilet tank flooding, etc. It will minimize the amount of damage and flooding by sensing the flow and turning off the water. Still further objects and advantages will become apparent from a consideration of the ensuing description and drawings.

DESCRIPTION OF THE DRAWINGS

FIG. 1 is a flow and control illustration of the system of the invention.

FIG. 2 is an electrical block diagram illustrating the input and output from the system components to the central processor unit.

FIG. 3 shows a cross-sectional illustration of the flow sensor device used in the invention.

FIG. 4 shows a cross-sectional view of a typical solenoid operated fluid shut-off valve used in the system of the invention.

FIG. 5 is an electrical schematic of the controller illustrating multiple input and output control and power sources.

FIG. 6 is a continuation of FIG. 5.

FIG. 7 is a flow chart of operational sequences.

REFERENCE NUMBERS used in the DRAWINGS	
10 Main control unit	11 Step-down transformer
12 not used	13 12 Volt DC input
14 Water main	15 Flow direction arrows
16 Manual shut-off valve	17 Automatic shut-off valve
18 Flow sensor	19 Data wires
20 Control wires	21 Valve body
22 Inlet port	23 Outlet port
24 Valve diaphragm	25 Upper chamber
26 Spring	27 A and B Fluid passage ways
28 Outlet chamber	29 A Solenoid 29B Pilot valve
30 Valve body	31 Inlet
32 Outlet	33 Valve seat
36 Leaf spring	37 Inlet (pressure port)
38 Piston chamber	39 Magnetic piston
40 Spring (calibration)	41 Outlet (pressure port)
42 Reed switch	43 Control head
44 "O"-Ring seals	45 Terminal strip
46 Terminal strip	47 Liquid crystal display
48 Terminal strip	49 Key pad
50 Temperature sensor	51 Test point
52 Option relay	53 Option terminals
54 Option terminals	55 Panic, remote terminals
56 By-pass, remote terminals	57 Control panel
58 Panic button	59 Reset button
60 By-pass button	61 Vacation hold button
62 Day button	63 Up button
64 Down button	65 Hour button
66 Minute button	67 Enter button
68 Program button	69 Pre-Program button

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to FIGS. **1**, **2** and **5** of the drawings, a fluid flow detection and shut-off system of the invention can be seen for use in residential or commercial structures. The shut-off system of the invention has a main control unit **10** with power supplied by a step down transformer **11** from a live power source of 110 volt AC to a transformer output at **13** of 12 volts DC which supplies the main controller **10** of the system. A water main **14** is illustrated having flow directional arrows at **15** defines the water input to the structure.

In this example, a service line shut-off valve **16**, manually operated gate, globe, ball or other type of valve supplied by others according to local plumbing codes this valve is normally open. And an automatic shut-off valve **17** are positioned in series in the water line **14**. A flow sensor **18** is positioned downstream of the automatic shut-off valve **17**. The flow sensor **18** is electrically connected to the control unit **10** via data wires **19**. Correspondingly, the automatic shut-off valve **17** has control wires **20** extending therefrom interconnected with the main controller **10** as will be described in greater detail hereinafter.

Referring to FIG. **4** of the drawings, a typical automatic shut-off valve **17** can be seen having a valve body **21** with inlet and outlet ports **22** and **23** respectively. A diaphragm valve element **24** in an upper valve chamber **25** is spring biased by a spring **26** towards a seat position whereby the flow of water from the inlet port **22** to the outlet port **23** is blocked. A fluid passageway **27** communicates between the upper valve chamber **25** and an outlet chamber **28** via a solenoid **29** activated valve element **29A**. Such solenoid activated valves illustrated in the preferred embodiment are of the type available through suppliers such as L. R. Nelson Company of Peoria, Ill. and Rainbird of Glendora, Calif. and is well known and understood to those skilled in the art. In operation, the automatic shut-off valve **17** in opening sequence, the fluid passage **27A** is opened by activation of the pilot valve **29A** lowering pressure through passage **27B** from the upper chamber **25** allowing the valve diaphragm **24** to move upwardly in the valve chamber **25** to an unseated position. When the solenoid valve **29A** is de-activated upon command of the controller **10** the pilot valve **29A** closes thus allowing the diaphragm **24** to be repositioned by the fluid pressure against the valve seat thus shutting off the fluid flow therethrough as is evident from the above referred to description.

Referring now to FIG. **3** of the drawings, the flow sensor **18** can be seen having a valve body **30** with an inlet opening **31** and an oppositely disposed outlet opening **32**. A valve seat **33** is formed between the inlet and outlet openings with a ball valve element **34** movable within valve guides **35**. A leaf type spring **36** extends from the control head **43** and is engageable against the valve ball element **34** urging same into the valve seat **33**. A back pressure port **37** upstream of the valve ball element **34** communicates with a chamber **38** having a magnetized piston **39** and a calibrated spring **40**. A back pressure outlet port **41** communicates with the chamber **38** allowing for movement of the magnetized piston **39** against the spring **40** when flow occurs indicated by the arrows in broken lines and the ball element position at **34A**.

A magnetic reed switch **42** positioned adjacent the chamber **38** within a control head body member **43** secured to the valve body **30** by a plurality of fasteners and interspersed gaskets **44**. In operation as flow occurs the ball valve element **34** initially restricts the fluid flow creating back pressure in the port **37** moving the magnetic piston **39** compressing the spring **40** closing the magnetic reed switch **42** which is connected to the main control unit **10** via a wiring harness **19**. In response the main control unit **10**, recognizes the "flow" signal from the magnetic reed switch **42**, compares it with the pre-programmed time and if such condition is met outputs a signal to the solenoid **29** of the automatic shut-off valve **17** closing the valve and stopping all flow of fluid to the system connected thereto. This type of flow sensor gives maximum low flow sensitivity and allows for full flow with minimum flow restriction.

Referring now to FIGS. **5** and **6** of the drawing, a circuit diagram is illustrated showing the preferred form of the invention. Accordingly, power may be supplied to the control system by multiple power sources. The primary power source is the hereinbefore described external 12V step down power transformer **11**, best seen in FIG. **1** of the drawings through the power input at **13**. An optional external battery (Extbatt) is used to supply power to the system should the main power be interrupted.

Accordingly, the external battery is kept from driving current back into transformer **11** by a diode **D1** (**1N4148** or equivalent) **+high** is the high DC voltage used to drive the automatic shut-off valve **17** hereinbefore described. The external battery circuit has a sub-system with a status bit that indicates any external battery problem with input to the microprocessor U1 of the controller **10** through a buffer at U4D. A resistor **R11** is a pull-up resistor providing a "no problem" status when the external battery sub-system is not connected.

The +high voltage passes through **D6** and is filtered by capacitor **C1** and provided to the voltage regulator **U3**. The voltage regulator **U3** generates the +5 volts DC needed by the system logic. The capacitor **C2** (representing several capacitors spread across the board) filters the +5 volts DC. U3 may also be supplied by a 9 volt stand-by-battery SB. In this situation, a diode D2 limits charging current into the 9 volt battery when operating from the transformer **11** power.

The resistors R1 and R2 provide a voltage divider of the 9 volt battery output voltage. The divided voltage is monitored by an A/D channel on the microprocessor U1 thereby indicting when the 9 volt battery's voltage gets too low, the microprocessor U1 will alert the user through the display to be described hereinafter. The microprocessor U1 used in this example can be identified by PIC19C924-04 or equivalent needs only power and a clock to operate.

A 32 KHz clock is provided by a crystal at Y1 along with its impedance matching capacitors C3 and C4. All programming accordingly is internal to the microprocessor U1 with a 5 volt DC power supplied as described above.

The system status is indicated by a plurality of icons on the liquid crystal display 47 such as time of day, program, flow, armed or unarmed, day of week, AM, PM, off, low batt. and cold.

The liquid crystal display 47 (LCD) is typically a five digit segmented display with 16 icons. The microprocessor U1 has an LCD controller built into it as will be well understood by those skilled in the art. There are nineteen control lines indicated at 48 between the liquid crystal display 47 and microprocessor U1. When a bit is set in a register in the microprocessor U1 the internal LCD controller drives the appropriate controls to illuminate the corresponding segment or icon in the LCD display at 47.

Such LCD displays 47 are well known in the art and are commercially available. Similarly, membrane push button switches, also called key pads or touch pads 49 are also well known in the art and are commercially available.

In the illustration chosen for the preferred embodiment, additional protection may be added to the system through the use of a temperature sensor 50 typically available as (36GS or the equivalent) attached to an A–D input of the microprocessor U1. The temperature sensor 50 outputs a signal as a voltage increase as the temperature increases. By reading the voltage level the microprocessor U1 knows what the temperature is, based on a pre-programming of the appropriate voltage values in relation to the determination of temperature indicated by the temperature sensor 50. When the temperature approaches freezing, the microprocessor U1 will activate the automatic shut-off valve 17 closing same and LCD will read COLD.

The microprocessor U1 has a test mode input at 51 with a resistor R14 that normally supplies a high signal on this input and the unit will operate normally. If this input is pulled low (by an external device such as a push button PB1) the microprocessor U1 will execute special test and diagnostic software which is pre-programmed. This input is intended for manufacturing and repair or testing the unit, which again is typical within the art of such microprocessors.

The automatic shut-off valve 17 is connected to the system of the invention through two pins (terminals) 48. One pin is ground and the other pin provides +high to the automatic shut-off valve when the automatic shut-off valve is to be turned on. The +high voltage is turned on and off by the microprocessor U1.

When the microprocessor U1 wants to turn on the automatic shut-off valve 17 it drives a high signal to the base of the transistor Q2 in this example (2N3906 or equivalent). A resistor R15 provides additional drive current to Q2. When Q2 turns on it pulls base current from a power transistor Q3 in this example (2N3468 or equivalent) thus turning on Q3 and supplying +high to the automatic shut-off valve 17 solenoid 29. The resistor R9 keeps Q3 turned off when Q2 is off.

There are provisions made for two additional user inputs, such as a remote panic switch 55 and a remote bypass switch 56. These inputs are made through a connector P2 which provides +5 vDC, ground and 2 inputs. Resistors R7 and R8 hold the external input lines high and accordingly the external device would pull the signal lines low (to ground) to indicate that they are active. The input signals are inputted through two gates U4B and U4C and then into the microprocessor U1. The U4 in this example illustrated as (1489 or equivalent) is a rugged input buffer which will tolerate +/−30 vDC input. Also provisions have been made for optional interface with external equipment through connector P1.

This connector serves both normally open and normally closed contact connections. The contact closures are provided by relay 52 with a 2 Form C contact configuration. The relay 52 drive coil is connected to +high and to Q1 (2N3906 or equivalent). When Q1 is turned on by the microprocessor drive current is supplied to relay 52. Resistor R1O guarantees relay coil has no drive current when Q1 is off. Q1 is driven by the microprocessor U1 with R16 providing additional high drive current. These contacts are provided for optional uses, which could be security system interface, audible alarm, water heater and/or water pump lock-out features, or any other uses the owuer sees fit.

The flow detection signal 18 is inputted through another gate of the buffer U4 with the signal line accordingly held high by resistor R6 when water is flowing the flow sensor switch 42 pulls the signal line to ground. The signal is buffered by U4A and is inputted to the microprocessor U1 as will be well understood by those skilled in the art.

Referring now to FIG. 2 of the drawings, a block flow diagram can be seen of the system input and output control signals to the microprocessor as hereinbefore described in greater detail and set forth in the hereinbefore illustrated as FIG. 5 of the drawings. It will thus be seen that a control panel 57 combines the key pad 49 and liquid crystal display 47. The key pad 49 has input key functions imprinted thereon to represent functional control access by the user as follows. A panic button 58 is used to manually shut-off the water supply when an unexpected water flow is detected by the occupant.

A reset button 59 allows the system to resume normal operation following the panic button 58 use or automatic activation of the automatic shut-off valve 17 in the water system. A bypass button 60 overrides the current programmed activity within the system for one hour and is used when the user would need to bypass the flow sensing system regardless if the system is armed or not.

A VAC (vacation hold) button 61 is used as a demand program override to arm the system until it is deactivated without requiring reprogramming of the system.

A DAY button 62 inputs the appropriate numerical value of the day of the week with adjustment arrow buttons 63 and 64 for increasing or decreasing said input criteria.

TIME input buttons allow for the hour input at 65, minute input at 66.

An ENTER button 67 enters the selections by the user into the microprocessor 10.

A PROGRAM button 68 is used for setting the desired days and on/off times for the system.

A PRE-PROGRAM button 69 is used to set any one of the three (3) pre-programmed settings for the system which have previously been determined.

This is a SET and FORGET system with user defined programs.

Pre Set System limits are:

Armed (on) maximum of three minutes continuous flow.

Unarmed (off) maximum of twenty minutes continuous flow.

Bypass On: maximum of one hour continuous flow.

Vacation Hold: maximum of three minutes continuous flow.

A typical program for the system could be:

Monday through Friday:		Saturday/Sunday:	
unarmed	6:30 AM	unarmed	7 AM
armed	8 AM	armed	11 PM
unarmed	12 PM		
armed	1 PM		
unarmed	5 PM		
armed	11 PM		

System can be programmed for up to six (6) on and six (6) off times per day for each of seven (7) days of the week, can be all different or any combination of days the same.

System programs are carry over type, for example, if program is set to arm at 11PM on. Tue.nite and next unarm setting was set for Fri. 8AM the system would be armed for the full duration. This type of flexibility cannot be achieved with the electromechanical timers used on the prior art devices.

It will thus be seen that a new and useful automatic shut-off valve sensing detection and activation system for a fluid distribution system has been illustrated and described and it will be apparent that various modifications may be made therein without departing from the spirit of the invention.

What is claimed is:

1. A water supply shut-off system controlled by a microprocessor, said water supply shut-off system being used in a building structure having a plurality of diverse plumbing devices therein, said water supply shut-off system includes a water supply shut-off valve and a water flow sensing valve,

said microprocessor includes means for programming said microprocessor to sense an electronic signal emanating from said water flow sensing valve and means to compare the value of said electronic signal to pre-programmed time durations based upon time of day/day of the week in said microprocessor and to thereafter impress an electronic signal onto said water supply shut-off valve including means for positioning said water flow sensing valve to be oriented in multi-directional positions from the vertical.

2. A water supply shut-off system as claimed in claim 1, wherein said time values are of different durations.

3. A water supply shut-off system as claimed in claim 1 including a manually operated panic switch to activate said shut-off valve when any of said plumbing devices develop an external water leak.

4. A water supply shut-off system according to claim 1 including means for sensing the ambient air temperature close to a point of freezing to shut off said supply.

5. A water supply shut-off system according to claim 1, wherein said water flow sensing valve includes a valve body having an upstream water inlet and a downstream water outlet and a spring biased ball valve placed there between.

6. A water supply shut-off system according to claim 5 including a back pressure inlet in said valve body and positioned upstream of said ball valve and a switch means responsive to fluid pressure in said back pressure inlet generating said electronic signal to said microprocessor.

7. A water supply shut-off system according to claim 1 including an internal battery to continue power to the program status in said microprocessor in case of a main power failure.

8. A water supply shut-off system according to claim 1 including an LCD display on said microprocessor having means to indicate the status of said water supply shut-off system, said LCD also acts as an interface to program said system.

9. A microprocessor for controlling an automatic water supply system having a shut-off valve and a water flow sensing valve, said microprocessor includes a user programmable control means for receiving, comparing and generating electronic signals, said water flow sensing valve sends appropriate electronic signals to said means for receiving in said microprocessor, said means for comparing compares said signals received with a predetermined duration of time and thereafter, the means for generating sends a corresponding signal to said water supply shut-off valve.

* * * * *

US008539827B2

(12) **United States Patent**
Benson et al.

(10) **Patent No.: US 8,539,827 B2**
(45) **Date of Patent: Sep. 24, 2013**

(54) **WATER METER WITH INTEGRAL FLOW RESTRICTION VALVE**

(75) Inventors: **Ronald D. Benson**, Colgate, WI (US); **Eric Metzger**, Milwaukee, WI (US)

(73) Assignee: **Badger Meter, Inc.**, Milwaukee, WI (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 426 days.

(21) Appl. No.: **13/017,264**

(22) Filed: **Jan. 31, 2011**

(65) **Prior Publication Data**

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(51) **Int. Cl.**
G01F 15/02 (2006.01)

(52) **U.S. Cl.**
USPC **73/199**; 251/129.01; 340/12.5; 73/203

(58) **Field of Classification Search**
None
See application file for complete search history.

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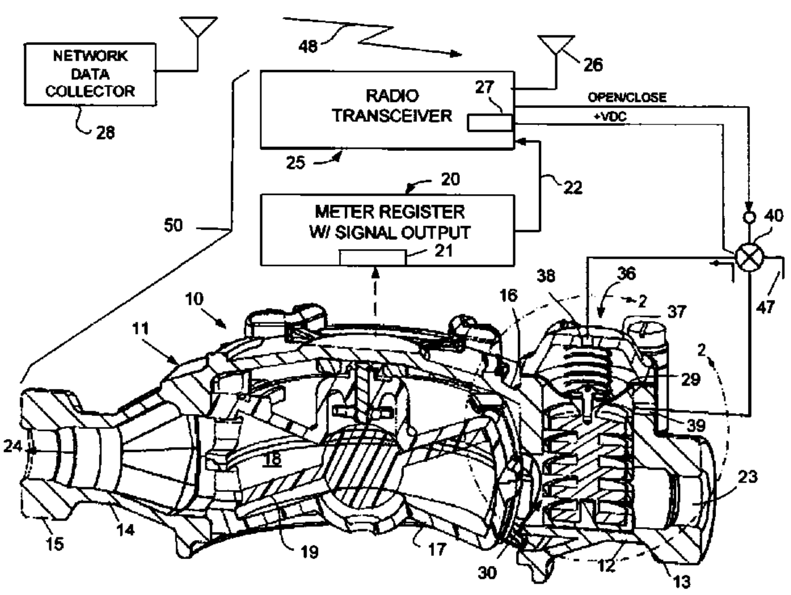
Primary Examiner — Harshad R Patel
(74) *Attorney, Agent, or Firm* — Boyle Fredrickson, S.C.

(57) **ABSTRACT**

A water meter (**10**) and a flow control valve (**30**) are housed in a common pressure vessel (**16**), in which the flow control valve (**30**) restricts flow through a metering chamber (**18**) to less than the normal flow, while still permitting a flow sufficient for basic human needs, rather than completely interrupting supply of the utility, and in which the flow control valve (**30**) is controlled electrically through a control valve (**40**) in an energy efficient manner so as to utilize power from a self-contained power source (**27**) in another device (**25**) at the customer site (**50**).

22 Claims, 3 Drawing Sheets



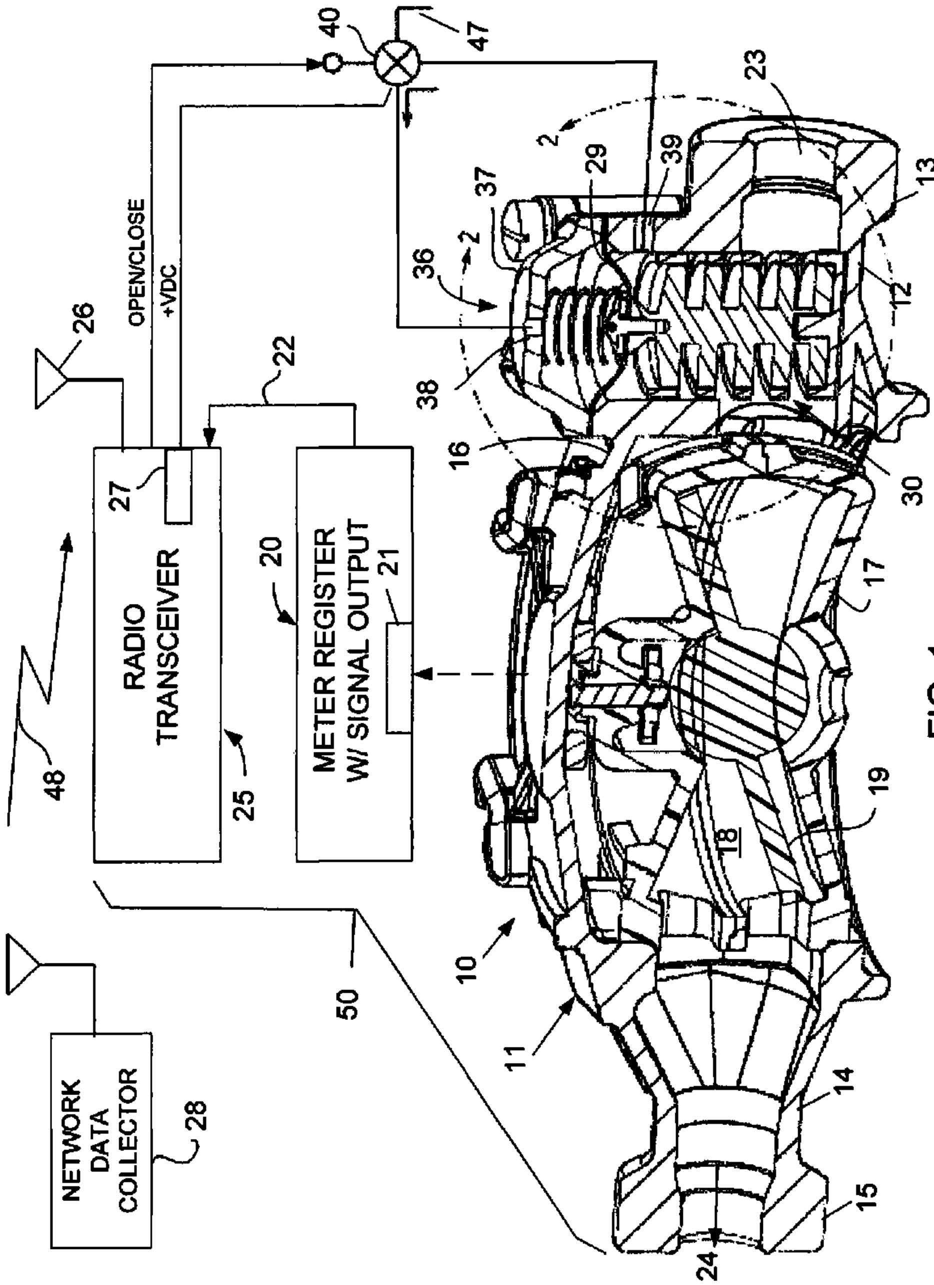

RADIO TRANSCEIVER
METER REGISTER W/ SIGNAL OUTPUT
NETWORK DATA COLLECTOR
OPEN/CLOSE
+VDC

FIG. 1

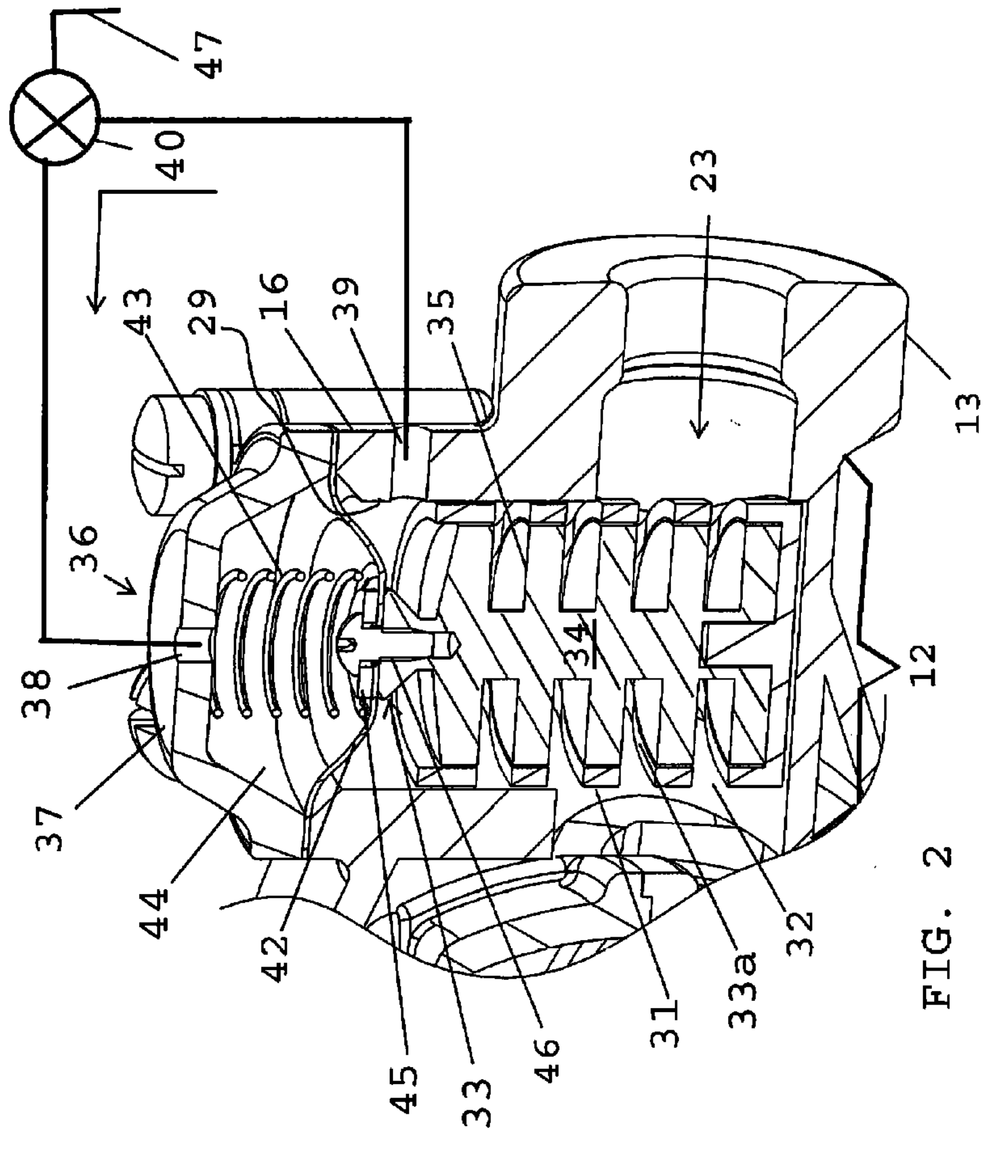


FIG. 2

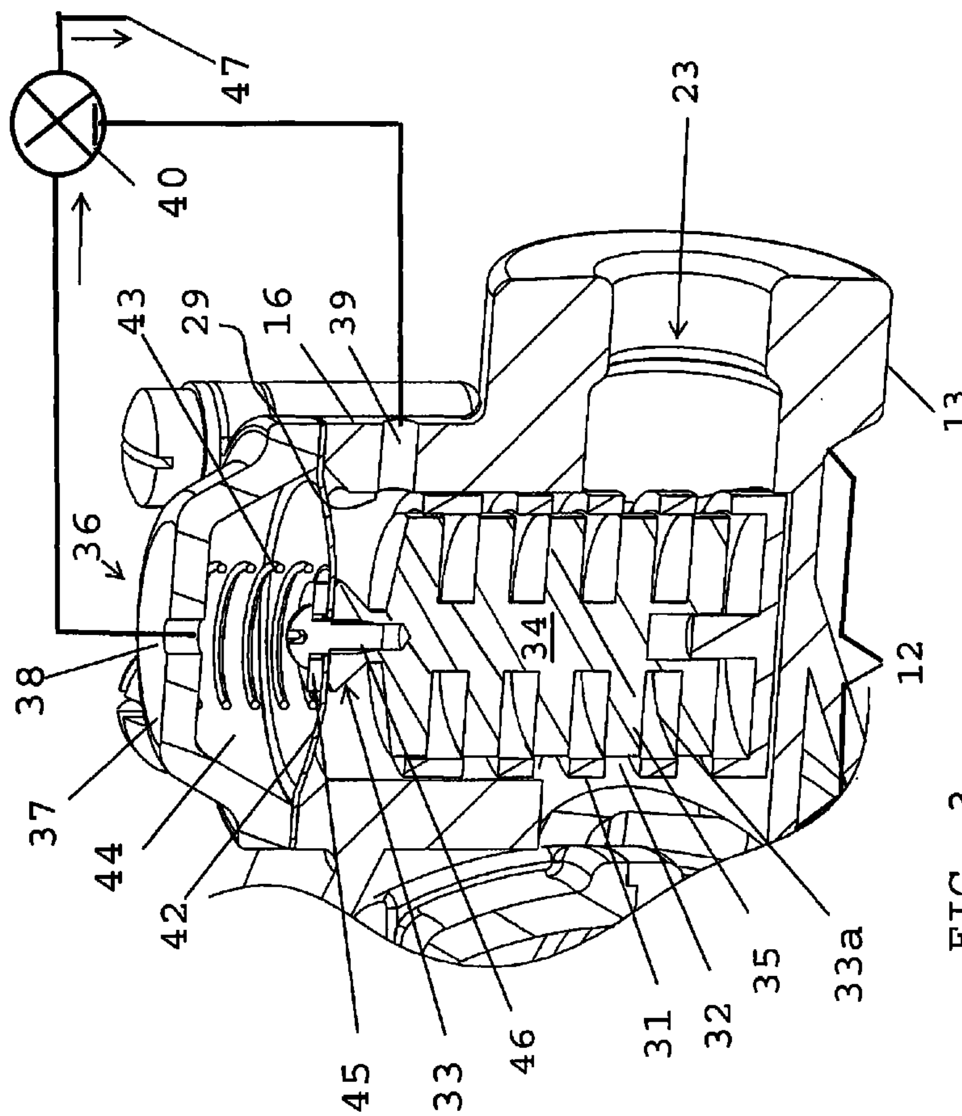


FIG. 3

WATER METER WITH INTEGRAL FLOW RESTRICTION VALVE

TECHNICAL FIELD

This invention relates to utility metering equipment and to shut-off valves for interrupting the supply of water from a public utility to a customer.

DESCRIPTION OF THE BACKGROUND ART

Utility metering equipment is often provided with a radio transmitter or a radio transceiver (receiver/transmitter) for transmitting meter consumption data to radio receiver in a meter data collection network. Some networks for collection metering data have provided the ability to control devices at the metering site by using a two-way communication through a site transceiver. In recent years, utilities and equipment providers have been considering alternatives for shut-off of service in emergency events, for conservation purposes, or in the event of non-payment of utility bills. Therefore, various methods for remote shut-off of the utility water supply are being investigated.

There are products currently be offered on the market to perform a water supply shut-off, but they require the use of a valve external to the water meter or a radio requiring an external source of power for operation. This requires the customer to run an additional power source to the meter and to modify their plumbing to accommodate the additional lay length of the external valve.

Marchesi, U.S. Pat. No. 3,795,144, discloses a manually operable shut-off valve having a housing that is integrated with a water meter housing. The purpose of this construction is to prevent removal of the valve without also removing the meter and thereby causing an inconvenience to the owner of flooding of the establishment (col. 5, lines 5-8). It is thus a tamper-resistance measure.

The constructions known in the art do not provide the convenience and functionality desired in controlling or limiting supply of a utility to a customer under the various conditions present today.

SUMMARY OF THE INVENTION

This invention houses a water meter and a flow control valve in a common pressure vessel, wherein the flow control valve is a flow restriction valve rather than a complete shut-off valve.

In one more detailed aspect, the invention provides a flow control valve having a valve member disposed in a portion of a pressure vessel for movement between an open position allowing normal, unrestricted flow through a metering chamber and a flow restriction position in which flow in the metering chamber is limited to significantly less than the normal flow. The flow restriction allows flow through the metering chamber that is significantly less than the normal flow, but is a measureable flow sufficient for basic human needs.

In another more detailed aspect, the combination has the same length as a water meter not having the flow restriction control valve so as to enable easy installation of the flow restriction apparatus. This allows the valve/meter assembly to simply replace an existing water meter, without requiring significant modifications to a customer's plumbing.

In a further more detailed aspect of the invention, an electrically operable control device is provided to cause the flow control valve to restrict flow through the metering chamber to less than normal flow; and the electrical control device receives power from a self-contained power source within a radio transceiver that is located at a customer's site with the water meter. This improves over shut-off devices requiring power from a building's power system, for example

In further details of this aspect of the invention, the flow control valve is controlled by an electrically operable solenoid and has an actuator which is operated by water pressure to reduce the electrical power required for actuation. This enables power to be obtained from a battery-powered remote transmitter and this is sufficient for actuation of the valve between an open position and a flow restriction position.

In a more detailed aspect of the flow control valve construction, a mechanism is provided for utilizing the valve to restrict and reduce flow, rather than to completely interrupt the flow. This is provided by a type of valve in which a plurality of spaces between spool bodies are moved with the valve spool from an aligned open position with openings in a valve cage to an offset position where the spool bodies restrict flow through the openings in the valve cage. Even in the misaligned position, the lack of a resilient seal between the valve parts means that some water will still pass through the valve. This can be adjusted by adjusting the tolerance and spacing of the valve parts to allow more or less water to pass down to a minimum. By restricting the flow of water to a very low volume, instead of completely shutting off the supply the above purposes might be served while humanely allowing the customer to have a limited water supply, for basic uses.

Other aspects of the invention, besides those discussed above, will be apparent to those of ordinary skill in the art from the description of the preferred embodiments which follows. In the description, reference is made to the accompanying drawings, which form a part hereof, and which illustrate examples of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a perspective sectional view of a metering assembly of the present invention with the control circuit being shown schematically;

FIG. 2 is a detail view of a valve, which is part of the assembly of FIG. 1, in the open position; and

FIG. 3 is a detail view of the valve of FIG. 2 in a flow restriction position.

DETAILED DESCRIPTION

FIG. 1 shows an assembly of the present invention. A disc-type water meter **10** includes a meter housing **11** comprising a pressure vessel made from at least one of a low-lead bronze alloy casting, other metals, other metal alloys or plastics. The meter housing **11** includes a tubular inlet conduit **12** leading to a threaded spud end **13**, a tubular outlet conduit **14** leading to a threaded spud end **15** and a cylindrical body **16**. Inside the cylindrical body, a disc-type meter assembly is disposed and a cover plate (not shown) is bolted to the bottom of the housing **11** to complete the enclosure as is known in the art. The spud ends **13**, **15** can be replaced by coupling flanges in larger sized meters.

The disc-type meter assembly includes a meter casing **17**. Inside this inner casing **17** is a main metering chamber **18**. The flow from the inlet **23** to the outlet **24** of the meter housing **11** through the metering chamber **18** is not necessarily a straight path, as the inlet and outlet into the disc metering chamber are often located near each other. For an example of this flow path, reference is made to U.S. Pat. No. 6,948,363, assigned to the assignee herein. Inside this chamber **18** is a nutating disc plate **19** of a type well known in the art in which

a flat disc-shaped member is integrated with and supported on a pivoting ball. The rotating movement of the disc plate **19** is sensed by a magnetic pickup **21** in a meter register **20** mounted on the meter housing **11**. The magnetic pickup **21** is connected to a gear train, as disclosed in Strobel, U.S. Pat. No. 4,868,566 and other patents granted to the assignee herein, which converts revolutions of the magnetic pickup **21** to rotations of a gear representing units of consumption for water flowing through the metering chamber **18**.

As known from Strobel, U.S. Pat. No. 4,868,566, these rotations are converted to electrical pulses which are counted as units of consumption of water. These signals **22** are transmitted through a cable to a radio transceiver **25** in the case of a separate assembly. In alternative embodiments, these signals **22** can also be transmitted through an internal electrical connection to a radio transceiver **25** that is assembled with the meter register **20** in a single housing or an integrated housing.

The radio transceiver **25** includes a radio transmitter portion and a radio receiver portion. The radio transmitter portion converts the utility consumption signals to a radio frequency signaling protocol for transmission back to a network data collector **28** through a wireless network. Although, this embodiment includes an electromechanical type of meter register, it should be understood that the invention can be practiced with electronic types of meter registers that have been more recently developed. As long as some type of electric signal generating meter register **20** is used, it will typically be used with a radio transceiver **25**, which is a necessary element in the present embodiments to receive command signals **48** to operate a flow restriction valve **30**.

Although a disc type water meter **10** is shown and described, the invention in its broadest scope can also be applied to other types of water meters, including turbine type meters, mag meters and ultrasonic meters.

The invention can be practiced with several categories of flow restriction valves including poppet valve, rotating ball valves, diaphragm-actuated valves, and sliding gate valves. In the present invention, a spool valve **30** which is a more complex version of a sliding gate valve is used to restrict flow, rather than to shut-off flow entirely to a customer.

The spool valve **30** is substantially vertically oriented in a location between the inlet spud end **13** and a cylindrical meter housing body **16**. A substantially vertically oriented cylindrical chamber **29** is formed there to receive the spool valve **30** which further comprises a fixed valve cage **31** with side openings **32** and a reciprocally moveable valve member **33**. The spool valve member **33** includes a spool valve shaft **34** and a plurality of disc-shaped spool bodies **35** spaced along the spool valve shaft **34**. When the spaces **33***a* in the spool valve member **33** are aligned with the side ports **32** in the cage **31**, as illustrated in FIGS. **1** and **2**, water flows through the inlet **23** to the disc metering chamber **18** in FIG. **1**. When the spool bodies **35** are aligned with the side ports **22** in the cage **21**, and the spaces **33***a* are offset from the side ports **22** in an axial direction, as illustrated in FIG. **3**, water flow into the disc metering chamber **18** and beyond is restricted as further described below.

The flow restriction valve **30** can be actuated using either a direct-acting electric solenoid or a hydraulic diaphragm that is controlled by a smaller pilot circuit that includes an electrically operable solenoid valve. The hydraulic actuation is preferred so that most of the energy required to actuate the valve is taken from the water pressure within the meter housing **16**. The hydraulic control circuit is further controlled by a solenoid-controlled hydraulic valve **40** that requires very little electrical energy, and can therefore be powered by a small-capacity battery source.

In more detail, and with reference to FIGS. **2** and **3**, the reciprocal movement of the spool valve member **33** is controlled by a hydraulically operable diaphragm actuator **36**. This diaphragm actuator **36** includes a non-moveable cap **37** having a port **38** for fluid communication with a diaphragm chamber **44**. The valve **40** is an electrically operable, solenoid-controlled, multi-position, hydraulic valve **40**. One of its ports is connected to the port **38** on the diaphragm valve cap **37** and another of its ports is connected to a port **39** on the meter body **16**. This port **39** opens into the spool valve chamber **29** below a flexible diaphragm **42**.

A return spring **43** is disposed in the diaphragm valve chamber **44** and is held between an underside of the diaphragm valve cap **37** and the flexible diaphragm member **42**. The bottom end of the return spring **43** is fastened with a washer **45** and a threaded fastener **46** to a top end of the spool valve member **33**. The return spring **43** is compressed when the diaphragm **42** is moved upward upon an exhausting of water through port **38**, thereby relieving hydraulic pressure in the diaphragm valve chamber **44**, which allows the diaphragm valve member **42** to move upward due to pressure from below. The diaphragm valve member **42** moves downward to a valve fully open position, when the hydraulic pressure is created in the diaphragm valve chamber **44** to equalize pressure created by water flowing through the main metering chamber **18**.

Therefore, it can now be understood how the operation of the spool valve **30** is controlled by the diaphragm actuator **42**, which in turn is controlled by the multi-position solenoid-operated hydraulic fluid control valve **40**.

When in the open position, the side openings **32** of both the valve cage **31** and spool valve member **33** are aligned, allowing complete flow of water from the inlet **23** and through the disc metering chamber **18**. The solenoid-controlled hydraulic valve **40** is not energized, and is in an open position such that fluid pressure present within the meter body **16** is applied equally to both sides of diaphragm **42**. With no fluid pressure available to move the diaphragm **42**, the spool valve member **33** is held in the open position by the valve positioning spring **43**.

As seen in FIG. **3**, in the closed position, the solenoid valve **40** has been energized and blocks the fluid pressure at port **39** from being applied to port **38**. The position of the valve **40** also allows the fluid pressure which had been previously available on the top side of the diaphragm **42** to exhaust to atmospheric pressure through outlet **47**, because the fluid pressure within the meter housing **16** is still available to the bottom side of the diaphragm **42**. This pressure differential results in a net force that compresses the valve positioning spring **43** and raises the spool valve member **33** within the valve cage **31** until the openings **33***a*, **32** in both the spool valve member **33** and the valve cage **31** are now alternated, with the spool bodies now partially blocking the flow of water to the disc metering chamber **18**.

The closed position of the valve **30** still allows a flow through the metering chamber which is less than the normal flow, but is a measureable flow sufficient for basic human needs. This restricted flow is considered to be in the range from 5% to 15% of normal flow, with 10% being typical. This type of restriction is provided by allowing a loose fit or enlarged tolerance in fit dimensions between the moveable valve member **33** and the valve cage **31**, which are made of rigid, non-elastomeric materials such as plastics and metal. This can also be affected by controlling the stroke or position of the valve member **33** relative to the openings **32** in valve cage **31**. This residual flow is also due to the lack of an

elastomeric seal in the valve assembly **30** of a type that would completely interrupt or completely shut off flow to the disc metering chamber **18**.

The solenoid-controlled hydraulic valve **40** receives command signals **48** from network data collector **28**, the signals being received by the radio transceiver **25**, and demodulated and decoded to provide an open or close signal to the valve **40** as seen in FIG. **1**. The valve receives dc electrical power required for operation through a +VDC line originating from the power source **27** powering the radio transceiver **25**. This power source **27** would typically comprise at least two 3.6-Volt, 2.4 Amp-hr lithium thionyl chloride batteries. It will be apparent to those of ordinary skill in the art, that in the future, other numbers and types of small, relatively low voltage and long-life batteries can be used.

Although the sliding gate valve **30** in this disclosure is shown to be cylindrical, it should also be understood that sliding gate valves of other shapes, such as flat plates or semi-circles can be shown to work as well. There may be molding or packaging advantages for valve shapes other than cylindrical. It is also contemplated that the control valve **40** and the flow restriction valve **30, 36** can be integrated within the water meter housing **16** to save space and simplify the assembly of the water meter/valve combination.

It should also be understood that the water meter **10** with restriction valve **30**, the meter register **20**, the radio receiver **25**, the control valve **40** are all located at a customer site **50**, which in some cases is a pit enclosure located in the ground. It should also be understood the that the network data collector **48** and radio transceiver **25** can be parts of a fixed network, or can be parts of a mobile network, where the network data collector **48** is carried in a vehicle or is carried by a person engaged in meter data collection.

This has been a description of preferred embodiments, and it will be apparent to those of ordinary skill in the art that variations may be made in the details of these specific embodiments without departing from the scope and spirit of the present invention, and that such variations are intended to be encompassed by the following claims.

We claim:

1. A flow restriction control apparatus for a water meter having a pressure vessel providing a flow path from a water supply inlet to a water supply outlet through a metering chamber, the flow restriction control apparatus comprising:
   - a flow control valve having a valve member disposed in a portion of the pressure vessel for movement between an open position allowing normal flow through the metering chamber and a flow restriction position in which flow in the metering chamber is limited to less than the normal flow;
   - an electrically operable control device for controlling operation of the flow control valve; and
   - wherein the electrically operable control device receives command signals to cause the flow control valve to restrict flow through the metering chamber to less than normal flow;
   - wherein the electrical control device receives power from a self-contained power source within a wireless reception radio transceiver that is located at a customer's site with the water meter.

2. The flow restriction control apparatus of claim **1**, wherein the flow through the metering chamber is not completely interrupted or shut-off.

3. The flow restriction control apparatus of claim **1**, wherein a portion of the pressure vessel is formed to contain the flow control valve in a pressure vessel having a same length as a water meter not having the flow restriction control so as to enable easy installation of the flow restriction apparatus.

4. The flow restriction control apparatus of claim **3**, wherein the flow control valve is a spool valve having a valve cage with side ports and a spool valve member with a plurality of spaced apart spool bodies which are aligned with the side ports in the flow restriction position and offset from the side ports in the open position to allow normal water flow.

5. The flow restriction control apparatus of claim **4**, wherein the spool valve member is positioned for movement substantially perpendicular to the path of water flow through the metering chamber.

6. The flow restriction control apparatus of claim **1**, wherein the flow control valve has a valve member that is positioned for movement substantially perpendicular to the path of water flow through the metering chamber.

7. The flow restriction control apparatus of claim **1**, wherein when the valve member is in the flow restriction position, flow through the metering chamber is less than the normal flow, but is a measureable flow sufficient for basic human needs.

8. The flow restriction control apparatus of claim **1**, wherein the electrically operated control device includes a solenoid-operated hydraulic valve connected in a hydraulic circuit with a diaphragm-type actuator on the flow control valve so as to minimize electrical power needed to actuate the flow control valve in the pressure vessel.

9. The flow restriction control apparatus of claim **1**, wherein the self-contained power source within the radio transceiver comprises at least two 3.6-Volt, 2.4 Amp-hr lithium thionyl chloride batteries.

10. The flow restriction control apparatus of claim **1**, wherein the pressure vessel is made of a cast metal.

11. The flow restriction control apparatus of claim **1**, further comprising a disk-type water meter with a nutating metering member housed within the pressure vessel.

12. The flow restriction control apparatus of claim **1**, further comprising a radio transceiver located at a customer's site with the water meter and configured to transmit command signals to cause the flow control valve to restrict flow through the metering chamber to less than normal flow.

13. The flow restriction control apparatus of claim **12**, further comprising a meter register assembled with the radio transceiver and mounted on the pressure vessel.

14. The flow restriction control apparatus of claim **13**, wherein the meter register is electrically connected with the radio transceiver through an electrical cable.

15. The flow restriction control apparatus of claim **12**, further comprising means configured for transmitting command signals to the radio transceiver to cause operation of flow control valve between the open position and the flow restriction position.

16. The flow restriction control apparatus of claim **1**, wherein flow is restricted to a flow within a range from 5% to 15% of normal flow.

17. A flow restriction metering apparatus comprising:
   - a water meter including a pressure vessel providing a flow path from a water supply inlet to a water supply outlet through a metering chamber;
   - a flow control valve having a valve member disposed in a portion of the pressure vessel for movement between an open position allowing normal flow through the metering chamber and a flow restriction position in which flow in the metering chamber is limited to less than the normal flow;

a radio-controlled control device for controlling actuation of the flow control valve; and

wherein the radio-controlled control device receives command signals to cause the flow control valve to restrict flow through the metering chamber to less than a normal flow, but does not completely interrupt or shut-off flow to the metering chamber.

18. The flow restriction metering apparatus of claim **17**, wherein the flow control valve has a valve member having a first, valve-open position relative to a valve body receiving the valve member to allow normal flow to a metering chamber, and wherein the valve member has a second, valve-closed position relative to the valve body in which flow is restricted to a minimum flow sufficient for basic human needs during a period of flow restriction.

19. The flow restriction metering apparatus of claim **18**, wherein the valve member and the valve body are made of rigid materials and tolerances such that a residual flow is allowed even when the valve member is in the closed position.

20. The flow restriction metering apparatus of claim **19**, wherein the flow control valve is provided without an elastomeric seal of a type that would completely interrupt or completely shut off flow to the metering chamber.

21. The flow restriction metering apparatus of claim **17**, wherein a portion of the pressure vessel is formed to contain the flow control valve in a pressure vessel having a same length as a water meter not having the flow restriction control so as to enable easy installation of the flow restriction apparatus.

22. The flow restriction metering apparatus of claim **17**, wherein flow is restricted to a flow within a range from 5% to 15% of normal flow.

* * * * *

US007626511B2

(12) **United States Patent**
Lazar

(10) **Patent No.:** **US 7,626,511 B2**
(45) **Date of Patent:** **Dec. 1, 2009**

(54) **AMR TRANSMITTER AND METHOD FOR BOTH NARROW BAND AND FREQUENCY HOPPING TRANSMISSIONS**

(75) Inventor: **Mark Lazar**, New Berlin, WI (US)

(73) Assignee: **Badger Meter, Inc.**, Milwaukee, WI (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 234 days.

(21) Appl. No.: **11/451,027**

(22) Filed: **Jun. 12, 2006**

(65) **Prior Publication Data**

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(51) **Int. Cl.**
G08B 1/00 (2006.01)

(52) **U.S. Cl.** **340/870.02**; 340/870.01; 340/870.18; 370/310; 370/338

(58) **Field of Classification Search** 340/870.02, 340/870.01, 870.18; 370/310, 338
See application file for complete search history.

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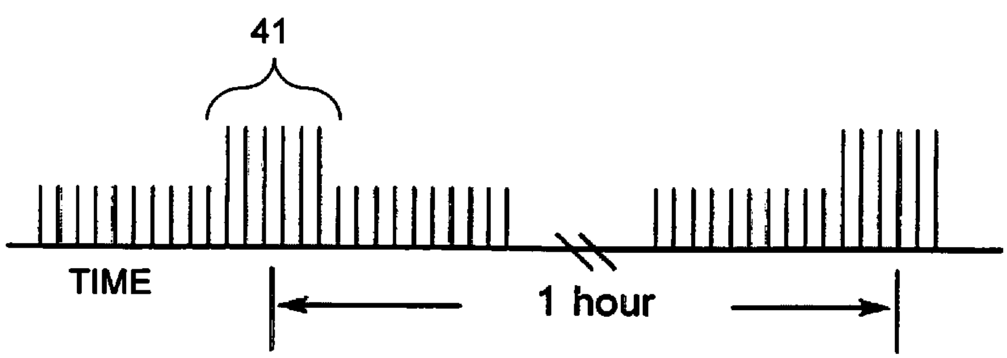
Primary Examiner—Brian A Zimmerman
Assistant Examiner—Hung Q Dang
(74) *Attorney, Agent, or Firm*—Boyle Fredrickson, S.C.

(57) **ABSTRACT**

The invention provides a method and circuitry for transmitting signals in both a narrow band, mobile-receiver type of AMR network and also for operation in the frequency-hopping, spread-spectrum, fixed-receiver type of AMR network. Unlike systems provided with multiple transmitters, the invention provides this in a single transmitter operating with common circuitry to transmit in two modes of transmission in a single operational sequence.

18 Claims, 4 Drawing Sheets



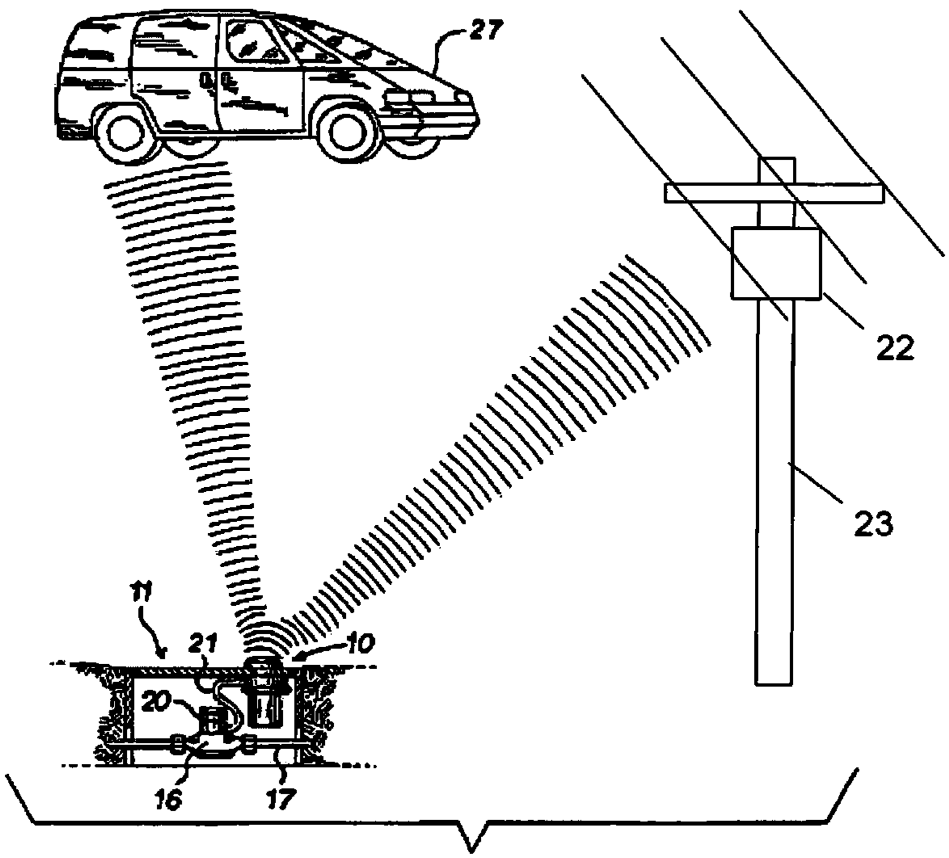


FIG. 1

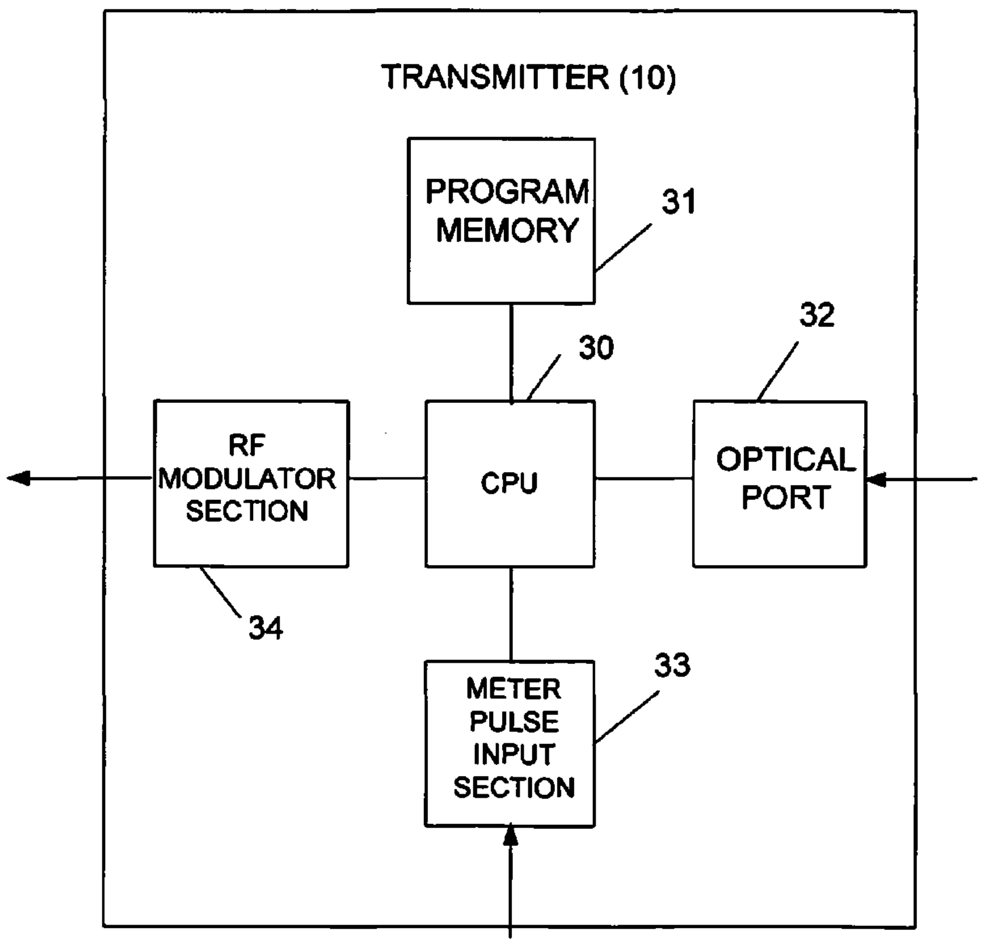

TRANSMITTER (10)
PROGRAM MEMORY
31
32
30
RF MODULATOR SECTION
CPU
OPTICAL PORT
34
33
METER PULSE INPUT SECTION

Fig. 2

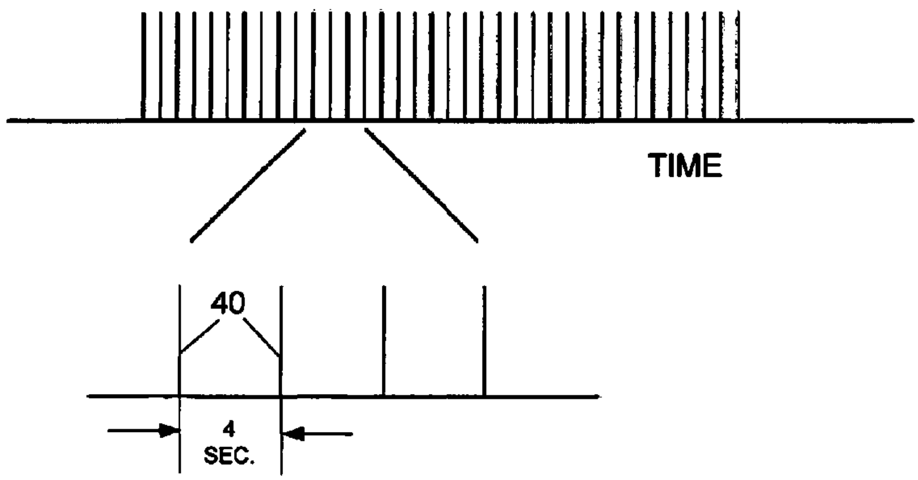


Fig. 3

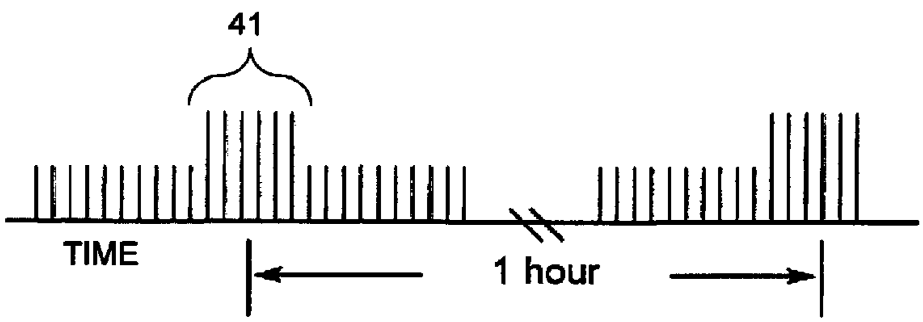


Fig. 4

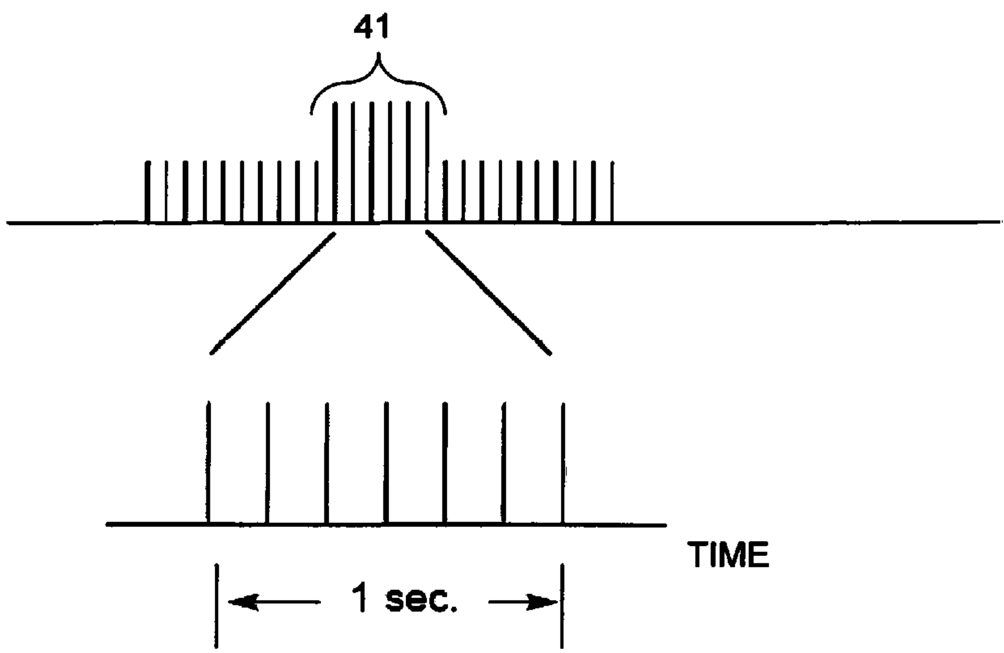


Fig. 5

AMR TRANSMITTER AND METHOD FOR BOTH NARROW BAND AND FREQUENCY HOPPING TRANSMISSIONS

TECHNICAL FIELD

This invention relates to automatic meter reading (AMR) systems, and in particular to utility meters using a radio transmitter for transmitting metering data signals to a radio receiver in a network for collecting utility metering data.

DESCRIPTION OF THE BACKGROUND ART

Cerny et al., U.S. Pat. No. 5,298,894, discloses a mobile automatic meter reading (AMR) system in which a utility meter transmitter receives pulses from a pulse transducer installed on a utility meter and transmits radio frequency (RF) meter data signals to an RF collection unit in a drive-by vehicle. In these mobile AMR systems, a vehicle or a person on foot with an RF collection unit (a walk-by collection system) can move through a neighborhood and collect a large number of readings per hour without entering any of the property of the customers.

Gastouniotis et al., U.S. Pat. No. 4,940,976, discloses a communications network for transmitting data from a plurality of remote meters to a central station through a plurality of fixed receiving stations. In fixed receiver network systems today, the receiver units can be mounted on utility poles, inside of electric meters or in utility pedestals. In such systems, it is not necessary to provide people and equipment to travel through the areas where readings are to be collected. There are, however, other issues is locating receivers and providing other equipment, such as repeaters, to provide coverage of the entire geographic area being serviced.

Mobile collection units and their associated transmitters operate in the unlicensed band around 915 Mhz, where transmissions are only required to reach distances of a few hundred feet, but must be sent out frequently to be available for a drive-by or walk-by collection unit at random times of collection. The unlicensed band is in a narrow range of the radio frequency spectrum, where power associated with the transmission signals is limited, to prevent interference in various areas where the equipment is operating with other RF signals in the environment. Fixed networks, on the other hand, transmit signals over distances of more than 1,000 feet and up to distances of one-half mile or more. Fixed network transmitters typically utilize a frequency-hopping, spread-spectrum type of transmission, which by regulation is permitted to use transmitter power levels 1000 times greater than the narrow band systems.

Mobile data collection systems and fixed data collection systems are competing in the marketplace today as gas, electric and water utilities move toward automation in the collection of metering data and the billing of utility customers.

Many utilities purchasing automatic meter reading systems today must consider system issues over a period of years. It would therefore be beneficial to the acceptance of such systems to provide these customers with the maximum long term system capabilities at a minimum reasonable cost including the costs associated with the installation, servicing and upgrading of the transmitters over the life of the system as a whole.

SUMMARY OF THE INVENTION

The invention provides a method and circuitry for transmitting signals in both a narrow band, mobile-receiver type of

AMR network and also for operation in the frequency-hopping, spread-spectrum, fixed-receiver type of AMR network. Unlike systems provided with multiple transmitters, the invention provides this in a single transmitter operating with common circuitry to transmit in two modes of transmission. The AMR network is preferably of the one-way type in which the transmitter initiates communication with the receiver.

The method more particularly comprises transmitting a first plurality of narrow band signals at a first, limited power level; and transmitting a second plurality of frequency-hopping, spread-spectrum signals at a second limited power level that is greater than the first power level by at least one order of magnitude.

The narrow band frequency signals are transmitted at first intervals of less than one minute over a plurality of hours, and the second plurality of frequency-hopping, spread spectrum signals are transmitted at second intervals which are longer than the first intervals by at least one order of magnitude.

The invention also relates to transmitter circuitry for carrying out the method of the invention.

In a further aspect of the invention, the transmitter circuitry further comprises a CPU operating according a stored control program; and a radio frequency modulation section for modulating meter data signals into radio signals for transmission, with these circuits acting as a single transmitter for transmitting both types of signals.

The circuit is low in cost, and very versatile in serving different types of networks, thereby saving utility customers costs in the event they may utilize more than one type of AMR system over the life of the transmitter.

Other objects and advantages of the invention, besides those discussed above, will be apparent to those of ordinary skill in the art from the description of the preferred embodiments which follows. In the description, reference is made to the accompanying drawings, which form a part hereof, and which illustrate examples of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a perspective view of an AMR system with both mobile and fixed receivers for receiving transmissions from a transmitter associated with a utility meter;

FIG. **2** is a block diagram of a metering data transmitter associated with a utility meter;

FIG. **3** is a schematic view of transmission pulses vs. time for the transmitter of FIG. **2** in a first mode of operation;

FIG. **4** is a schematic view of transmission pulses vs. time for the transmitter of FIG. **2** in first and second modes of operation; and

FIG. **5** is a schematic detail view of transmission pulses in the second mode of operation seen in FIG. **4**.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring to FIG. **1**, one example of an environment of the invention is provided by a subsurface pit enclosure **11**. The pit is typically made of metal, concrete, plastic or other materials and a lid which is removable to open the enclosure **11** for access. The pit enclosure **11** is located along the route of water supply pipe **17**. A water meter housing **16** is connected in the water supply line **17**. A water meter register unit **20** is mounted on top of the water meter housing **16**. As known in the art, meter registers convert mechanical movements of a

meter to visual and numerical representations of consumption often shown in an odometer type read-out device. The register **20** is preferably a unit that is commercially distributed by Badger Meter, Inc., the assignee of the present invention, under the trade designation "Recordall" Transmitter Register (RTR). Besides displaying units of consumption, this device **20** uses a pulse transmitter that is described in Strobel et al., U.S. Pat. No. 4,868,566, entitled "Flexible Piezoelectric Switch Activated Metering Pulse Generators," to convert the mechanical movements of the meter to electrical signals. Other metering transducers known in the art an using optics and an analog-to-digital encoder (ADE) circuit can also be used as the register **20**.

The register **20** connects via a shielded cable **21** to a transmitter assembly **10**, which is housed in a tubular housing of plastic material that hangs down from the pit lid. The register **20** transmits electrical signals to the transmitter assembly **10**, for further transmission through a radio network. Besides the cable **21**, it is also known in the art to transmit these signals wirelessly to an antenna mounted in the pit lid as well.

The transmitter assembly **10** communicates via low power RF signals with a receiver which can be a mobile receiver (not shown) in a vehicle **27**. The pit transmitter assembly **10** transmits an electronic message that includes an identification code, meter reading data, and an error code for checking the data at the receiving end. The meter data is collected from various customer locations for billing purposes.

In the present invention, the transmitter assembly **10** can also communicate via higher power RF signals with a fixed receiver **22** installed on a utility pole **23** within a range of one thousand feet of the transmitter unit **10**. The pit transmitter assembly **10** transmits an electronic message that includes an identification code, meter reading data, and an error code for checking the data at the receiving end. The meter data is collected from various customer locations for billing purposes.

Referring to FIG. **2**, the transmitter assembly **10** also includes an electrical circuit typically formed on a circuit board and including a microelectronic CPU **30** operating according to a control program stored in a program memory **31**, which in this case is an electrically erasable and programmable read only memory (EEPROM). Thus, the memory is nonvolatile but can only be altered with a special programming unit, which communicates with the transmitter through an optical I/O port **32**.

As further seen in FIG. **2**, the CPU **30** receives pulses from a pulse encoder (not shown) through a meter pulse input section **33**. This input section can receive a pulse input or an input from an analog-to-digital encoder (ADE) circuit of a type known in the art. It then transmits metering data in a message protocol, which is converted to radio frequency (RF) signals by an RF modulator section **34**.

The AMR transmitter **10** has two modes of operation and operates on a one-way AMR network. In a one-way AMR network, with narrowband receivers, the transmitter **10** will transmit in the narrow band mode of operation most of the time. In this mode, the transmitter will normally be in a sleep mode from which it will periodically wake-up and send a message on a single frequency within the 902-928 Mhz frequency band and in accordance with FCC regulations. This is a one-way network in which the transmitter initiates communication with the receiver. The power level of the transmission is limited by FCC regulations. This limit for this mode of operation is determined to be 94 dB microvolts/meter. At a transmission distance of three meters through a 50-ohm load, this is considered to be a transmission power level limit of approximately one (1) milliwatt. Drive-by vehicles **27** will be able to read the transmitter signal and collect meter readings. The type of system uses a battery for power and this mode of transmission provides long battery life using small batteries. This signal may be read by fixed receivers **22** provided they are not too far from the transmitter. However, due to the need to cover geographic areas, the receivers may be further away than the optimum range for narrow band operation and may require transmission at a higher power level.

Therefore, it would be desirable to provide a second transmitter or a second type of transmission for fixed network systems utilizing a higher power level. In the present invention, this is accomplished by periodically sending out a higher power signal according to a frequency-hopping spread-spectrum mode of operation, which is the subject of different FCC regulations permitting a higher power level. This power level is limited to ¼ watt for a number of channels from 25 to 50 channels and to one (1) watt for systems utilizing at least 50 channels. In the present embodiment, the lower number of channels and the lower power limit is selected, but in other embodiments of the invention the higher number of channels can be used to further utilize the higher power limit. This transmission can be made at longer intervals than the narrow band transmissions which must be available to a drive-by or walk-by receiver at random times. The fixed receiver is always present, so a frequency of transmission on the order of an hour or longer is acceptable. After the higher power transmission, the transmitter **10** returns to narrow band operation transmitting lower power pulses at 4-second intervals.

It is a further aspect of the invention that these signals are transmitted by the same transmitter in a single operational sequence.

Referring to FIG. **3**, the narrow band operation is represented by pulses **40** sent out at intervals of every **4** seconds, for example.

Referring to FIG. **4**, the full transmitter signaling operation is shown over a period of one hour with low power pulses transmitted every 4 seconds and with a group of twenty-five high power pulses **41** sent out over twenty-five spread spectrum frequencies within a one-second interval (FIG. **5**), but the group of high power pulses are separated from the next such group by a longer interval of approximately one hour, as illustrated in FIG. **4**. Only some of the twenty-five pulses **41** in each group of twenty-five have been illustrated to represent the group.

An alternative method would provide a high power transmission at six-minute intervals (ten times) within one hour once a day (once each 24 hours).

One advantage of the invention, is that it requires only a single transmitter and provides both modes of operation with common circuitry.

Another advantage of the invention is that it conserves battery life.

This has been a description of the preferred embodiments, but it will be apparent to those of ordinary skill in the art that variations may be made in the details of these specific embodiments without departing from the scope and spirit of the present invention, and that such variations are intended to be encompassed by the following claims.

I claim:

1. A utility meter interface unit configured to connect in a one-way automatic meter reading network, the utility meter interface unit comprising:

transmitter circuitry configured to transmit a first plurality of narrow band signals at a first, limited power level for reception by a drive-by receiver and configured to transmit second pluralities of frequency-hopping, spread-spectrum signals at a second limited power level that is

greater than the first power level by at least one order of magnitude for reception by a receiver in a fixed network; and

wherein the transmitter circuitry is configured to transmit the narrow band frequency signals at first intervals of less than one minute over a plurality of hours, except when interrupted for transmitting one of the second pluralities of frequency-hopping spread-spectrum signals at a second interval which is longer than the first interval by at least one order of magnitude;

wherein the first plurality of narrow band signals and one of the second pluralities of frequency hopping signals are each transmitted during respective intervals within a single operational sequence; and

wherein transmitting the narrow band signals for reception by a drive-by receiver at the first intervals more frequently than the spread spectrum signals transmitted for reception by a receiver in a fixed network at the second intervals provides communication for drive-by receivers while conserving power in the utility meter interface unit.

2. The utility meter interface unit as recited in claim **1**, wherein the transmitter transmits the second pluralities of frequency hopping spread spectrum signals at one hour intervals.

3. The utility meter interface unit as recited in claim **1**, wherein the transmitter transmits a plurality of the frequency hopping spread spectrum signals a plurality of times within one hour of a twenty-four hour time period.

4. The utility meter interface unit as recited in claim **1**, wherein the first intervals are four seconds.

5. The utility meter interface unit as recited in claim **4**, wherein the second intervals are approximately one hour.

6. The utility meter interface unit as recited in claim **1**, wherein the first power level is limited to be no greater than one milliwatt.

7. The utility meter interface unit as recited in claim **6**, wherein the second power level is in a range from at least ten times the first power level to one watt.

8. The utility meter interface unit as recited in claim **1**, further comprising:

a CPU operating according a stored control program; and

a radio frequency modulation section for modulating meter data signals into RF signals for transmission.

9. The utility meter interface unit recited in claim **1**, wherein the first plurality of narrow frequency band signals and the second plurality of frequency hopping spread spectrum signals are transmitted by common circuitry comprising a single transmitter.

10. The utility meter interface unit of claim **1**, wherein the first plurality of narrow band signals and the second pluralities of frequency hopping signals are transmitted within a frequency range between 902 Mhz and 928 Mhz.

11. A method of transmitting radio frequency signals representing utility metering data, the method comprising:

transmitting a first plurality of narrow band signals at a first, limited power level for reception by a drive-by receiver; and

transmitting a second plurality of frequency hopping spread spectrum signals at a second limited power level that is greater than the first power level by at least one order of magnitude for reception by a receiver in a fixed network; and

wherein the narrow band signals are transmitted at first intervals of less than one minute over a plurality of hours, and wherein the second plurality of frequency-hopping, spread spectrum signals is transmitted at a second interval which is longer than the first interval by at least one order of magnitude;

wherein the first plurality of narrow band signals and one of the second pluralities of frequency hopping signals are transmitted during respective intervals within a single operational sequence; and

wherein transmitting the narrow band signals for reception by a drive-by receivers at first intervals more frequently than the spread spectrum signals transmitted for reception by a receiver in fixed network at the second intervals provides communication for drive-by receivers while conserving power in a utility meter interface unit.

12. The method as recited in claim **11**, wherein the second pluralities of frequency-hopping, spread-spectrum signals are transmitted at one hour intervals.

13. The method as recited in claim **11**, wherein a plurality of the frequency-hopping, spread-spectrum signals are transmitted a plurality of times within one hour of a twenty-four hour time period.

14. The method as recited in claim **11**, wherein the first intervals are four seconds.

15. The method as recited in claim **14**, wherein the second intervals are approximately one hour.

16. The method as recited in claim **11**, wherein the first power level is limited to be no greater than one milliwatt.

17. The method as recited in claim **16**, wherein the second power level is in a range from ten times the first power level up to one watt.

18. The method of claim **11**, wherein the first plurality of narrow band signals and the second pluralities of frequency hopping signals are transmitted within a frequency range between 902 Mhz and 928 Mhz.

* * * * *

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Vincent et al.

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(43) **Pub. Date: Dec. 4, 2008**

(54) **WATER LEAKAGE AND FAULT SENSING SYSTEM**

(76) Inventors: **Raymond A. Vincent**, Plymouth, MI (US); **Mark M. Mrocca**, Belleville, MI (US); **John Abbott**, Westland, MI (US); **Jeffrey Iott**, Monroe, MI (US)

Correspondence Address:
Masco Corporation
21001 Van Born Road
Taylor, MI 48480 (US)

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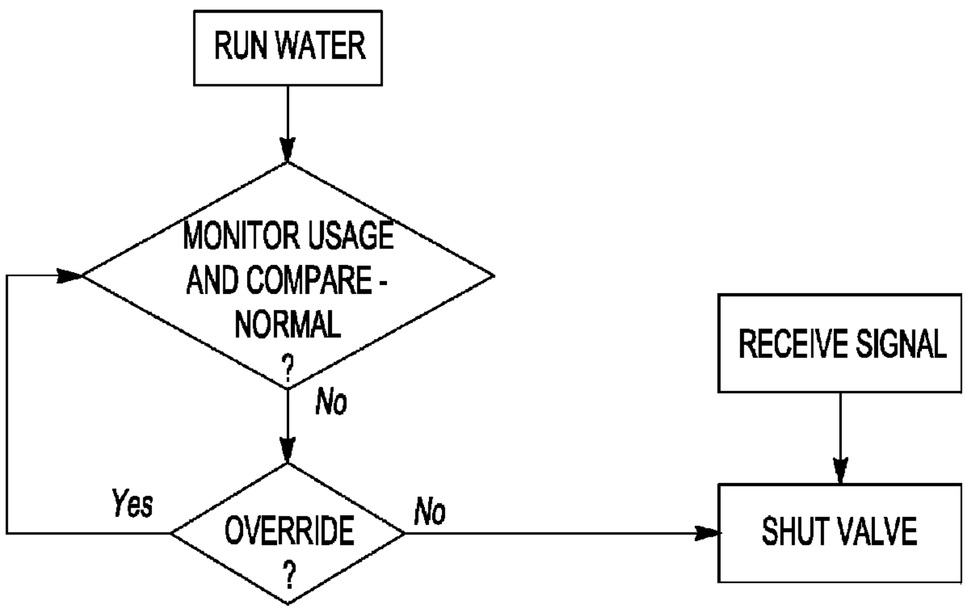
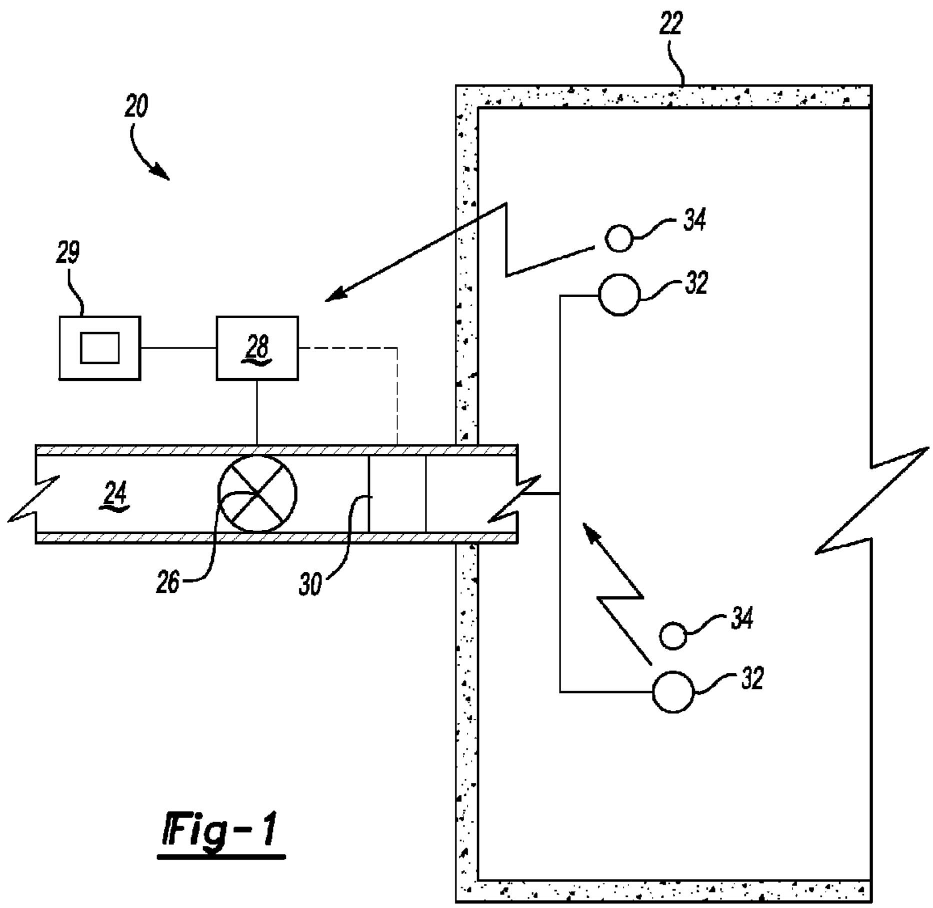
F16L 5/00 (2006.01)

(52) **U.S. Cl.** **137/357**; 137/487.5

(57) **ABSTRACT**

A system is provided for monitoring leakage within a building. Remote sensors are placed at locations that are likely to have leaks occurring. If a leak is detected by one of the remote sensors, a signal is sent to a control for a main shut-off valve. The main shut-off valve is placed on the main water supply line leading into the building. Further, a flow meter is placed on the main water supply line. The flow meter monitors water being delivered into the building, and should an abnormal water flow be detected, the control will close the shut-off valve. The flow meter and control may learn normal water usage patterns for the building, or the patterns may be pre-programmed into the system. A manual override allows the control to be bypassed when it is intended for a large volume of water to be moved into the building, such as when a swimming pool is filled, etc.




22
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32

Fig-1

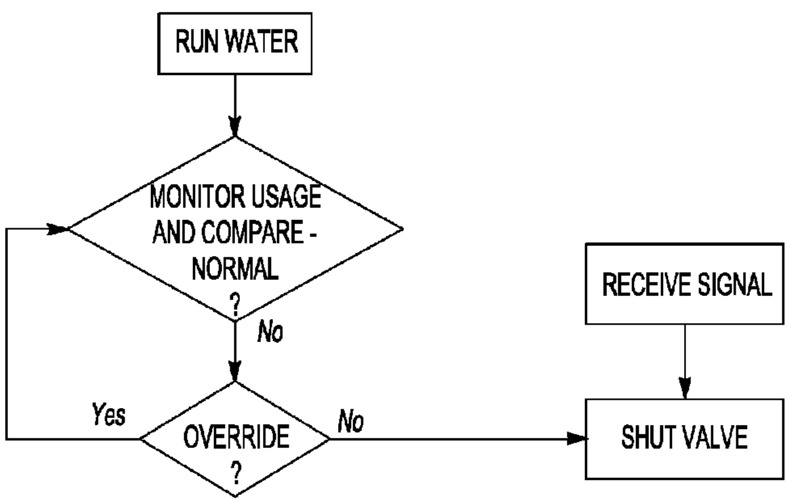
RUN WATER
MONITOR USAGE AND COMPARE - NORMAL ?
No
Yes
OVERRIDE ?
No
RECEIVE SIGNAL
SHUT VALVE

Fig-2

WATER LEAKAGE AND FAULT SENSING SYSTEM

BACKGROUND OF THE INVENTION

[0001] This application relates to a water leakage and fault sensing system wherein sensors sense leakage in various locations within a building, and further the water usage is monitored to determine abnormal water usage patterns. If a problem is identified, then a main shut-off stops water flow to the building.

[0002] Buildings utilize water in a variety of locations. Items which use water, such as tubs, pools, washing machines, etc. can sometimes leak. Further, water flow lines can break, causing catastrophic leakage.

[0003] Various methods have been proposed in the prior art to monitor for such fault or leakage. One general type of prior art system monitors the flow volume through the system, and looks for sudden increases. Those sudden increases may be interpreted as resulting from a leak. Another general type of system utilizes leakage sensors at locations within the building. If the leakage sensors sense leakage, a remote signal is sent to a shut-off valve. These two general features have not been utilized in combination. Moreover, the prior art has generally not been provided with the ability to override these control features.

SUMMARY OF THE INVENTION

[0004] In the disclosed embodiment of this invention, a shut-off valve for a main water supply line to a building is provided with remote signals from leakage sensors. If leakage is detected within the building, signals are sent to a control, and the shut-off valve can be closed.

[0005] Further, the same system incorporates a flow meter that monitors water usage. The general water use patterns within the building may be learned by the control, or the control may simply look for pre-programmed abnormalities.

[0006] In another feature of this invention, a manual override is provided to the control. This allows intended "abnormal" water usage, such as may occur when filling a pool, etc.

[0007] These and other features of the present invention can be best understood from the following specification and drawings, the following of which is a brief description.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] FIG. **1** is a schematic view of the inventive system.

[0009] FIG. **2** is a flowchart of the invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

[0010] A water monitoring system **20** is illustrated in FIG. **1**. System **20** includes a mains water supply line **24** leading to a building **22**. A shut-off valve **26** is placed on the main water supply line **24**. A control **28** for the shut-off valve **26** receives a signal from a flow meter **30**. Flow meter **30** is a proportional flow meter, and monitors water usage. Either the flow meter **30** or the control **28** may learn regular water usage patterns for the building **22**, or may be pre-programmed to identify particular usage patterns that may be expected. Deviation from these expected patterns, i.e., an increase in flow, may be indicative of a leak.

[0011] A manual override switch **29** allows manual override of this control **28** to allow intended "abnormal" usage such as filling a pool, etc.

[0012] Remote locations **32** may be provided with remote leakage sensors **34** that are able to communicate through an RF or other wireless connection to the control **28**. Sensors **34** are preferably placed at locations where a leak might most likely occur. For example, the vicinity of an outside pipe which could break in the winter, the location of a tub, dishwasher, washing machine, etc. would be likely locations for inclusion of a sensor **34**.

[0013] The present invention thus incorporates both the flow monitoring and the leakage-sensing concept into a single system. Further, by learning water usage patterns for the building, the system is more accurate with regard to identifying leaks, and eliminating false leaks. In addition, manual override switch **29** also eliminates a source of unintended shutdown of the shut-off valve **24**. Of course it would be undesirable to have the water supply to a building improperly shutdown, and thus making the system more accurate is a beneficial step.

[0014] FIG. **2** shows a flowchart of the inventive control. The inventive control algorithm **28** may be set to "learn" normal usage patterns over the first few months after it has been installed in the building, or it may also be programmed with ranges of normal use for the particular type of building. Deviation from this normal usage by a predetermined amount which would be indicative of a potential leak, and the control would thus shut the valve **26**.

[0015] Although a preferred embodiment of this invention has been disclosed, a worker of ordinary skill in this art would recognize that certain modifications would come within the scope of this invention. For that reason, the following claims should be studied to determine the true scope and content of this invention.

What is claimed is:

1. A water supply system for a building comprising:

a main water supply line;

a shut-off valve mounted on said main water supply line, said shut-off valve having a control, said control receiving a signal from a flow meter; and

a plurality of leakage sensors located at various locations within the building, said leakage sensors sending a signal to said control, said control being operable to receive said signals from said leakage sensors and from said flow meter, and determine whether a leak is occurring within the water supply system, said control operable to close said shut-off valve if a determination is made that a leak is occurring.

2. The water supply system as set forth in claim **1**, wherein said sensors send wireless signals to said control.

3. The water supply system as set forth in claim **1**, wherein said flow meter is positioned directly downstream of said main shut-off valve.

4. The water supply system as set forth in claim **1**, wherein said flow meter is utilized to generate and store normal water usage patterns in the building, and said normal water usage patterns being compared to monitored water usage to determine whether a leak is occurring.

5. The water supply system as set forth in claim **1**, wherein a manual override switch allows the control to be manually overridden, such that large volumes of water can be moved without a shutdown of the shut-off valve.

6. A water supply system for a building comprising:

a main water supply line;

a shut-off valve mounted on said main water supply line, said shut-off valve having a control, said control receiv-

ing a signal from a flow meter mounted downstream of said main water supply line;

a plurality of leakage sensors located at various locations within the building, said leakage sensors sending a wireless signal to said control, said control being operable to receive said signals from said leakage sensors and from said flow meter, and determine whether a leak is occurring within the water supply system, said control operable to close said shut-off valve if a determination is made that a leak is occurring;

said flow meter utilized to generate a memory of normal water usage patterns in the building, and said normal water usage patterns being compared to monitored water usage to determine whether a leak is occurring; and

a manual override switch allowing the control to be manually overridden, such that large volumes of water can be moved without a shutdown of the shut-off valve.

7. A method of controlling water flow into a building comprising the steps of:

(1) providing a shut-off valve on a main water supply line to a building;

(2) providing remote sensors at various locations within the building, said remote sensors being operable to sense leakage and send a signal to a control for said shut-off valve;

(3) providing a flow meter, said flow meter communicating with said control; and

(4) sending water usage information from said flow meter to said control and comparing current water usage to normal water usage, and identifying a leak if said current water usage differs substantially from said normal water usage, and sending signals from said remote sensors to said control if said remote sensors sense leakage within the building.

8. The method as set forth in claim **7**, wherein said flow meter and said control learn normal water usage patterns for the building which are then utilized as said normal water usage.

9. The method as set forth in claim **7**, wherein a manual override is provided for manually overriding the control and allowing large volumes of water to be delivered into the building.

* * * * *

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(12) **United States Patent**
Sanderford, Jr.

(10) **Patent No.: US 9,253,754 B2**
(45) **Date of Patent: Feb. 2, 2016**

(54) **MULTI-BAND CHANNEL CAPACITY FOR METER NETWORK**

(75) Inventor: **H. Britton Sanderford, Jr.**, New Orleans, LA (US)

(73) Assignee: **Sensus USA Inc.**, Raleigh, NC (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **13/333,226**

(22) Filed: **Dec. 21, 2011**

(65) **Prior Publication Data**

US 2012/0163213 A1 Jun. 28, 2012

Related U.S. Application Data

(60) Provisional application No. 61/426,746, filed on Dec. 23, 2010.

(51) **Int. Cl.**

H04W 72/02	(2009.01)
H04W 24/00	(2009.01)
H04W 28/16	(2009.01)
H04W 40/12	(2009.01)
H04Q 9/00	(2006.01)

(52) **U.S. Cl.**
CPC ***H04W 72/02*** (2013.01); ***H04Q 9/00*** (2013.01); *H04Q 2209/25* (2013.01); *H04Q 2209/40* (2013.01); *H04Q 2209/60* (2013.01); *H04Q 2209/823* (2013.01); *H04W 24/00* (2013.01); *H04W 28/16* (2013.01); *H04W 40/12* (2013.01)

(58) **Field of Classification Search**
CPC H04W 72/02; H04W 24/00; H04W 28/16; H04W 40/12; H04Q 9/00; H04Q 2209/40; H04Q 2209/60; H04Q 2209/823; H04Q 2209/25
See application file for complete search history.

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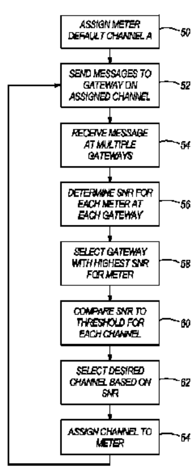
Primary Examiner — Marsha D Banks Harold
Assistant Examiner — Walter Divito
(74) *Attorney, Agent, or Firm* — Andrus Intellectual Property Law, LLP

(57) **ABSTRACT**

A communication system that relays data messages from or to a plurality of remote endpoints via RF gateways to a data accumulation site over one of a series of communication channels. The communication system monitors the signal-to-noise ratio of communication from each individual endpoint, which can be utility meters and related control or monitoring points, to a gateway. Based upon a quality of service and/or the signal-to-noise ratio of the communication of the endpoints to the gateways, the system assigns a desired communication channel to the endpoint. Each of the desired communication channels have varying data transmission rate and required SNR and each channel is selected based upon the signal-to-noise ratio of the transmissions from the endpoint to the gateways. If the signal-to-noise ratio changes for an endpoint, the system dynamically reassigns a different channel to the meter based upon the updated signal-to-noise ratio.

8 Claims, 4 Drawing Sheets



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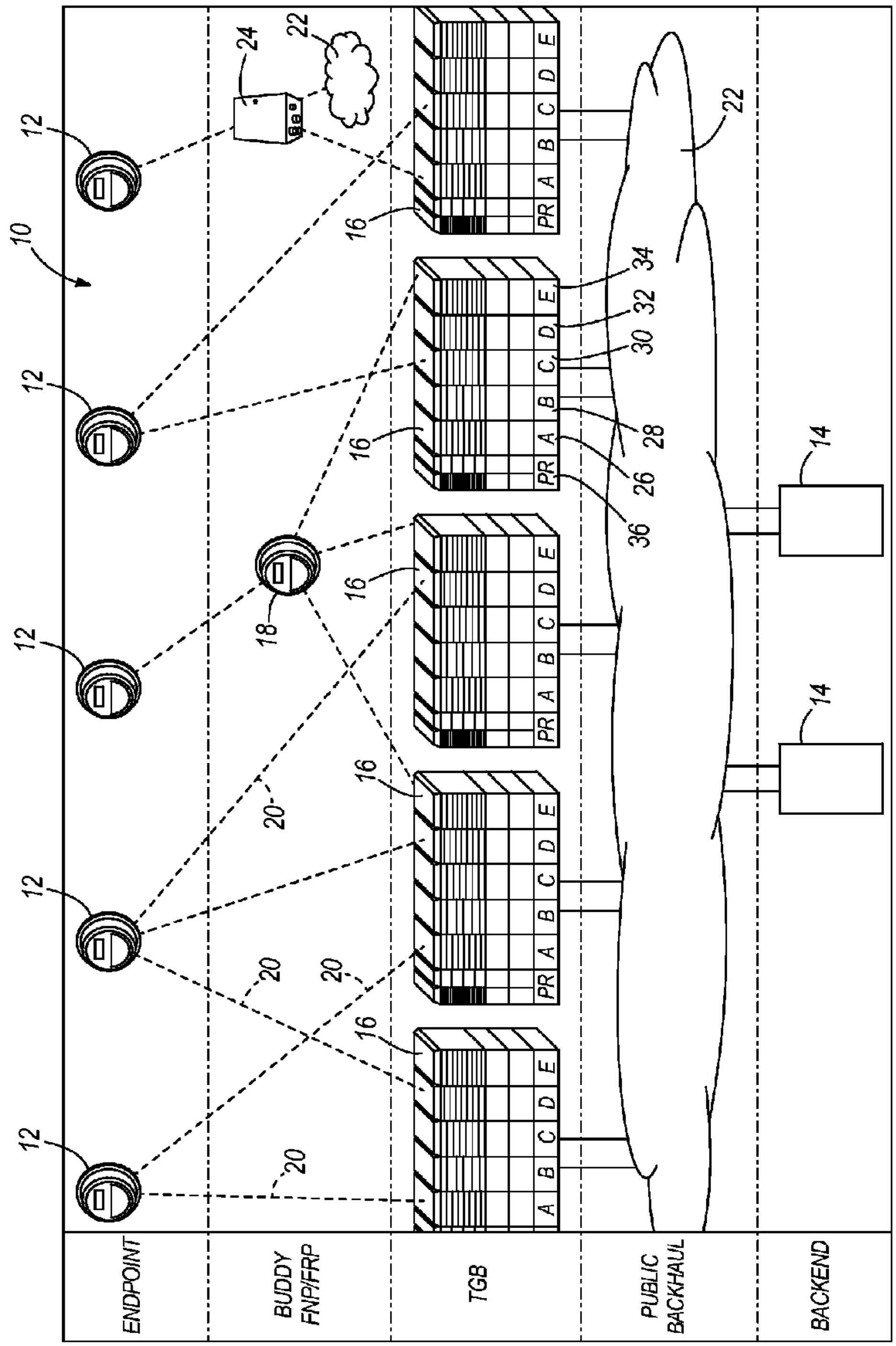
ENDPOINT
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PUBLIC BACKHAUL
BACKEND
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FIG. 1

150 kHz

	12.5 kHz	12.5 kHz	25 kHz	25 kHz	25 kHz	25 kHz	25 kHz
MODULATION	29 FSK	7 FSK	7 FSK	13 FSK	13 FSK	29 FSK	29 FSK
RATE	16 Kb/s	4 Kb/s	8 Kb/s	16 Kb/s	16/24 Kb/s	16/24 Kb/s	24/36 Kb/s
INBOUND	ALARMS CMDS	POLL RETRY	ALOHA READ PUSH/PING	ALOHA READ PUSH/PING	ALOHA READ PUSH/PING	ALOHA READ PUSH/PING	ALOHA READ PUSH/PING
	24.5 ms	215.2 ms	107.6 ms	56.7 ms	40.8 ms	25.5 ms	20.2 ms
	40 Msg/s	5 Msg/s	9 Msg/s	18 Msg/s	24 Msg/s	40 Msg/s	49.5 Msg/s
OUTBOUND	5/12.5 Kb/s		12.5 Kb/s	12.5 Kb/s	12.5/25 Kb/s	12.5/25 Kb/s	12.5/25 Kb/s
SNR	PRIORITY	REPLY	LOW SNR	MID SNR	MID SNR	MID SNR	HIGH SNR
IDENTITY	PRIORITY	REPLY	CH. A	CH. B	CH. C	CH. D	CH. E

FIG. 2

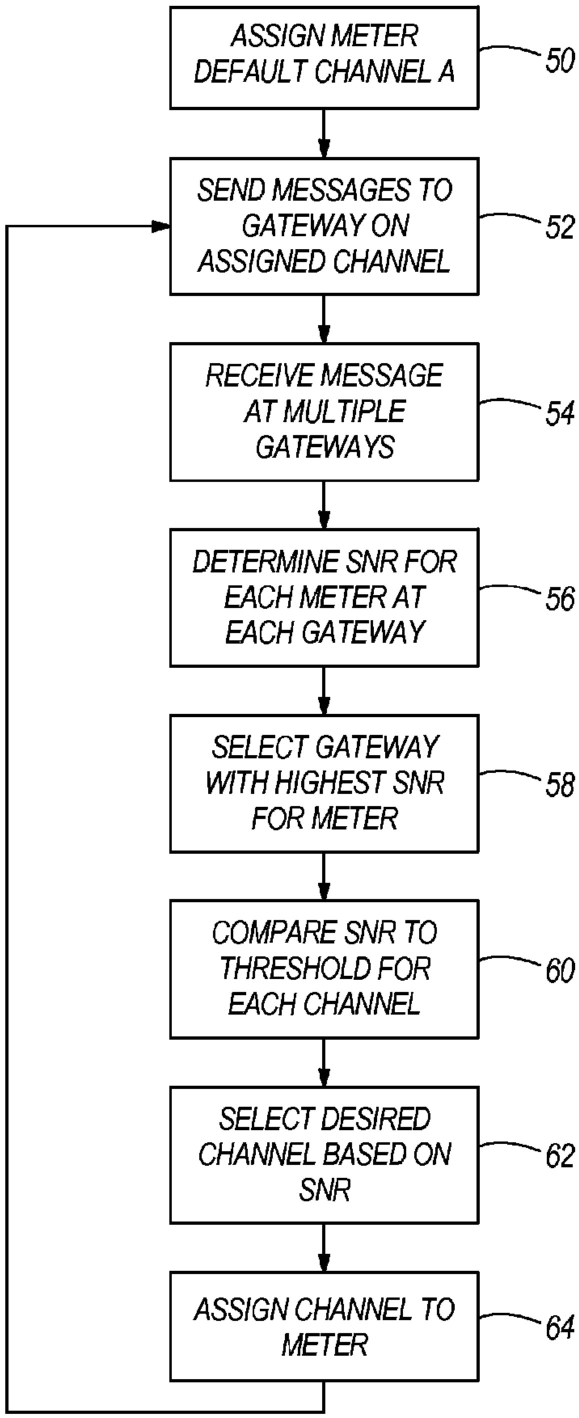
ASSIGN METER DEFAULT CHANNEL A
50
SEND MESSAGES TO GATEWAY ON ASSIGNED CHANNEL
52
RECEIVE MESSAGE AT MULTIPLE GATEWAYS
54
DETERMINE SNR FOR EACH METER AT EACH GATEWAY
56
SELECT GATEWAY WITH HIGHEST SNR FOR METER
58
COMPARE SNR TO THRESHOLD FOR EACH CHANNEL
60
SELECT DESIRED CHANNEL BASED ON SNR
62
ASSIGN CHANNEL TO METER
64

FIG. 3

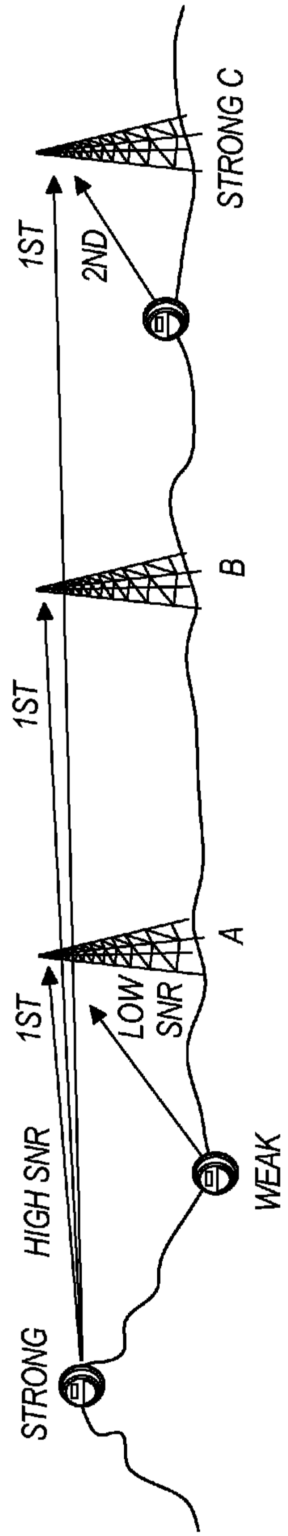

FIG. 4

MULTI-BAND CHANNEL CAPACITY FOR METER NETWORK

CROSS-REFERENCE TO RELATED APPLICATION

The present application is based on and claims priority to U.S. Provisional Patent Application Ser. No. 61/426,746 filed Dec. 23, 2010.

BACKGROUND OF THE INVENTION

The present disclosure generally relates to a method of controlling the radio communication of data messages between a plurality of field endpoints (in some cases utility meters) and a network of fixed location gateways which in turn communicate with a centrally located network controller. More specifically, the present disclosure relates to a method that optimizes the use of the communication channels by each of the plurality of endpoints to increase the overall effective message transmission capacity and where needed to increase the direct reach between a gateway and endpoint, thus enabling single-tier communications.

Presently, automated meter reading (AMR) systems exist that allow meters, such as electricity, gas and water meters, to communicate consumption information to a back end server through intermediate gateways. Typically, intermediate gateways communicate with the multiple meters using RF communication and re-transmit the received data over a public network, such as the internet. Although such systems, such as the FlexNet® AMI system available from Sensus USA, have proven effective at obtaining and processing meter data at a central, remote location, the increasingly common usage of such systems has increased the demand on the AMI or smart grid systems. As an example, in a system that includes 200 gateways and millions of individual meters, the communication taking place between the meters and the gateways has resulted in embodiments in which over 1 million messages are received by the gateways in aggregate per hour. Because of expanding applications, future smart grid systems are anticipated to exchange over 1 billion messages per day. Due to this increasingly high volume of communication between the meters and the gateways, techniques are required to more effectively utilize available bandwidth to enhance the communication between the various devices within the communication system. In addition, since real time control is required to protect the grid and to automatically respond to fault conditions, it is also important to minimize response time latency. This is also best accomplished by reducing the number of nodes where data must be handed off. Each hand-off requires that a node must receive a message, demodulate the message, apply error correction and possibly data decryption, repackage the message, set up the transmitter hardware and retransmit the messages, each step requiring processing time. Whereas mesh systems rely on multiple data hand offs between nodes, it is an object of this disclosure to minimize the number of handoffs thus improving latency. The minimal number of tiers is known to be one. Thus, an object of the disclosure is to provide reliable operation with a single communications tier.

Presently, when an individual meter is placed in a network system, the meter is assigned a communication channel over which communications between the meter and each of the gateways in the physical vicinity of the meter takes place. When an operator is setting up such a system, each meter is assigned a specific channel over which communication takes place. Although trained personnel attempt to select the communication channel based upon the proximity of the meter to a gateway or anticipated signal-to-noise ratio between the meter and a particular gateway, once the meter has been deployed, the communication channel frequency typically does not change unless the installer returns to reconfigure the meter or additional set-up is required at the network controller back-end. Therefore, although the operator may attempt to optimize the system upon deployment, if physical characteristics of the area change or if other variables are modified, the system will drop out of optimization, which is not desired.

SUMMARY OF THE INVENTION

The present disclosure relates to a system and method for controlling the communication of data between a multiplicity of endpoints (sometimes water gas or electricity meters, load controllers, PCT, utility displays, or the like) contained within a communication system and a single tier of intermediate gateways. The system optimizes the communication channel used to transmit the data between the meters and the gateways to ensure that each of the meters is transmitting data at the maximum rate while at the same time insuring a minimum "quality of service" and reliably, even to endpoints that in locations which are hard to reach and thus have lower signal to noise ratio (SNR).

During initial installation of meters in the communication system, each meter is initially assigned a default communication channel over which communications between the meter and the gateway will take place. The default communication channel is selected to have relatively long message duration since the signal-to-noise ratio between the meter and the gateway is initially unknown and the longer message duration improves link margin SNR.

After the meter has been installed into the communication system, the meter transmits communication messages between the meter and one or more gateways. In many cases, each of the meters will be able to communicate with more than one gateway of the communication system. The gateways are equipped with a means to measure signal quality. These means may include SNR, signal strength, quieting, or raw % message success or the like. The gateways forward this information to the central network controller.

After a series of messages are sent between each meter and the receiving gateways, the network controller analyzes the messages received by each of the gateways from each individual meter. Specifically, in the preferred embodiment the system determines the signal-to-noise ratio of the messages sent between the meters and the receiving gateways. The network controller also analyses raw % communications success and/or gaps in message delivery.

After a desired number of messages have been received, or a predetermined time has passed, the system determines the signal-to-noise ratio between each endpoint and the associated best receiving gateway. The best receiving gateway is the gateway that receives messages from the individual meter and has the highest signal-to-noise ratio.

Based upon the signal-to-noise ratio for the messages received at each of the gateways, the system determines whether the communication channel assigned to the meter is the most desirable. If the communication between the meter and the gateway has a relatively high signal-to-noise ratio, the system will assign a communication channel to the meter which is associated with high SNR meters. Preferably, the endpoint is programmable, by commands from the network controller, to communicate with a gateway or gateways over a plurality of different communication channels. The preferred embodiment of the disclosure typically uses sets of

three gateway receive channels. The channels are distinguished by the type of endpoint which is assigned to them. High signal strength to best server endpoints are assigned to one channel, mid signal strength to best server endpoints are assigned to another channel and low SNR to best server endpoints are assigned to yet a third channel. In this manner, a weak SNR meter does not compete with a strong SNR meter, thus increasing noise, which reduces the reliability of the weak meter and reduces the SNR the weak meter would otherwise have available for communications.

In addition, the present disclosure teaches the use of higher order modulations when higher levels of SNR are available. It is known since the discovery of the "Shannon Bound" that SNR is related to the maximum data rate which can be sent for a given bit error rate (BER) reliability. Therefore, the preferred embodiment network controller commands an endpoint to utilize a modulation which conveys greater data rates, providing that the endpoint has demonstrated sufficient SNR to support that modulation. The instant disclosure uses N-FSK to accomplish this increase in data rates, where N is 2, 4, 8 and 16 and where the same bandwidth is used for each N. The instant disclosure is equally applicable to other modulations forms such as ASK, PSK etc. Therefore, for a given bandwidth, the effective data rate increases where the only cost is SNR. Each endpoint with a higher SNR effectively increases the overall capacity of the network since more messages can be delivered in a 24 hour period. Therefore, the preferred embodiment also segregates modulation methods by the frequency channel utilized. Each of the plurality of different communication channels has a resultingly different message duration and transmission rate. The low SNR channel, for example, cannot carry as much data capacity as the strong SNR channel. It is believed this is fundamentally optimal use of widely distributed SNRs from endpoints dynamically increases net effective message capacity while maintaining a minimum required quality of service (BER).

The communication channel assigned to each of the meters is determined based upon the signal-to-noise ratio between it and the best server TGB. If the signal-to-noise ratio is high, the system assigns the communication channel having the shortest message duration. Each of the communication channels includes an upper threshold value and a lower threshold value for the signal-to-noise ratio that should be present in order for the communication channel to be assigned to the meter.

During operation of the system, if the signal-to-noise ratio of messages transmitted by an individual meter to a gateway changes, the system re-assigns a communication channel based upon the adjusted signal-to-noise ratio. As an example, if the signal-to-noise ratio increases, the system will assign a communication channel having shorter message duration and increased transmission rate. Likewise, if the signal-to-noise ratio decreases, the system will select a communication channel having a lower communication rate and longer message duration. If the meter is already assigned the communication channel having the lowest communication rate and longest message duration, the system can optionally forward poll messages from a gateway and respond messages to the gateway via an intermediate endpoint that is equipped with store and forward capability.

In accordance with the present disclosure, the system assigns the communication channel to each of the individual meters based upon the signal-to-noise ratio of messages sent from the meter to the most optimal gateway. If the signal-to-noise ratio changes during use, the system will re-assign a communication channel based upon the adjusted signal-to-noise ratio.

Any channel on system may be used in a poll-respond fashion or in a "self-initiated" ALOHA fashion.

The present disclosure also describes two-way operation. The disclosure optionally controls the outbound RF power from a first gateway such that only enough power is used to reach the targeted endpoint. This conservation of RF power reduces the effect of the RF power on distant endpoint's receivers that are served by a second gateway closer to it, and not intended to hear the outbound message of the first gateway. The prior art describes many ways to provide power control which lead to a fair amount of complexity (such as that used by QUALCOMM which consumes channel capacity to provide real time control of an endpoints RF output power). The present disclosure uses a simple, predominantly static relationship: due to signal reciprocity, if the link margin from the endpoint to the gateway is strong then an inverse amount of power is required to communicate from the gateway to that endpoint. Therefore, when a poll message from a gateway is sent to that endpoint, it is transmitted at a reduced power. In addition, since the excess SNR is available, the poll message can be transmitted from the gateway at a higher data rate (as discussed above for the inbound messages to a gateway).

Further, the preferred employment assigns outbound channels, from a gateway to the endpoint, based on this inverse power relationship. In this manor all "strong" SNR endpoints listen on a channel that can optionally be set to a higher data rate modulation and yield a high quality of service even though the gateway transmits a lower amount of power. For example, if an endpoint has an excess of 20 db SNR above what is needed to demodulate the modulation it is set to, then the gateway can transmit 20 db less outbound power. This in effect reduces the effect of the gateway transmission on an endpoint that may be four times as distant.

The reduced outbound power allows for more frequency re-use, which increases overall network capacity, and the reduced noise increases available SNR to an endpoint's receiver thus increasing the quality of service delivered. Similar benefits accrue to low SNR endpoints such that a gateway may use a greater amount of outbound RF transmit power to communicate to a hard to reach meter, without having to use mesh-like intermediate tiers of communication. The present disclosure goes a step further, whereby the gateway is equipped with an additionally 10 dB of outbound power beyond that required for a balance from-to link margin. This allows a gateway to reach inside of a building to issue a poll message whereby an endpoint is able to reply to a gateway. Even if that polling gateway cannot hear the reply, in the preferred embodiment, all gateways listen on all frequencies at all time. Thus, a gateway that did not transmit the poll message may receive a reply from an endpoint and forward that reply to the network controller. This is particularly useful if a gateway should fail.

The present disclosure provides immediate seamless recovery, since any gateway may issue a poll message from an adjacent area next to the failed gateway and since any adjacent gateway may hear the reply. In addition, the network controller poll algorithm automatically increases a gateways transmitted RF power if an earlier poll transaction fails. In addition, the endpoints have several reply modes which a poll message can dynamically invoke. For example a poll that failed on a high SNR channel will be automatically resent by the network controller to reply on a low SNR modulation, thus reducing needed SNR and thus increasing the effective link margin. This is a very powerful method to dynamic insure a quality of service even when a gateway fails or another condition exists that may affect the signal paths of the net-

work. For example, in the preferred embodiment, reducing a data rate from 25 kb/s to 4 kb/s can provide a dynamic link budget of 15 db utilizing the same signal bandwidth. Further reduction in data can provide an additional 10 db of link margin "reach." This feature is not feasible on a mesh network and helps to eliminate the need for multiple tiers and enables single tier operation.

It should be noted that the network controller may be part of a home network, a building network, a neighborhood, a city, a state or a country.

Various other features, objects and advantages of the invention will be made apparent from the following description taken together with the drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

The drawings illustrate one mode presently contemplated of carrying out the disclosure. In the drawings:

FIG. **1** is a schematic illustration of a communication system for relaying meter information from a plurality of meters to a back end data accumulator;

FIG. **2** is a schematic illustration of the individual channels used to communicate between the meters and intermediate gateways;

FIG. **3** is a flowchart describing one embodiment of the operation of the communication system; and

FIG. **4** is a graphic illustration of the strong and weak communication between meters and a receiving tower.

DETAILED DESCRIPTION OF THE INVENTION

FIG. **1** illustrates a communication system **10** for communicating between a plurality of meters **12** and a back end data accumulation site or server **14**. In the embodiment shown in FIG. **1**, the meters **12** can be any type of utility meter, such as an electricity meter, gas meter, or water meter. The data accumulation server **14** can be located at a utility, third party data accumulation company or any other location that receives the accumulated meter data and processes the data for analysis, billing or any other purpose. The communication system **10** shown in FIG. **1** could be the FlexNet® communication system available from Sensus USA. However, other different types of communication systems are contemplated as being within the scope of the present disclosure.

In the embodiment shown in FIG. **1**, each of the meters **12** communicates information either to one of a plurality of gateways **16** or to an intermediate meter **18**. The intermediate meter **18** relays information from each of the end point meter **12** to one or more of the gateways **16**. The intermediate meter **18** thus provides additional range of communication for each of the meters **12** that cannot communicate directly to one of the gateways **16**.

As illustrated in FIG. **1**, the communication between each of the meters **12** and one of the gateways occurs over one or more wireless communication paths **20**. The wireless communication between the meter **12** and the gateway **16** occurs utilizing an RF data transmission signal.

Each of the gateways **16** in turn is able to communicate over a public wide area network (WAN) **22**. In the embodiment shown, the public WAN **22** is the internet. Thus, each of the gateways **16** is able to communicate with the one or more data accumulation sites **14** through the public WAN **22**, as is known.

In addition to the intermediate meters **18**, the communication system **10** shown in FIG. **1** could also include a repeater **24** that can be used to either communicate information from the individual meter **12** through the gateway **16** or directly through the public WAN **22**.

As illustrated in FIG. **1**, each of the meters **12** preferably can communicate to more than one gateway **16** such that if one of the communication paths **20** to a gateway **16** is interrupted for any reason, the meter **12** can still communicate to another gateway **16**. The redundant communication between each of the meters **12** and the gateways **16** facilitates a more robust and reliable communication system.

Although the system shown in FIG. **1** includes five individual gateways **16**, it should be understood that in relatively large systems, the system could include dozens or hundreds of individual gateways **16**, each of which serve multiple meters **12**. FIG. **1** is a simplified illustration to facilitate understanding of the present disclosure.

In the schematic illustration shown in FIG. **1**, the communication between the individual meters **12** and one or more of the gateways **16** can occur over one of five individual communication channels, illustrated by reference characters A-E in FIG. **1** and referred to by reference numerals **26-34**. Each of the individual channels **26-34** may have slightly different communication protocols that enable the communication system **10** to optimize the communication between the individual meters **12** and the plurality of gateways **16**. In addition to the five channels A-E, the communication system also includes a sixth channel **36** that is divided into two subchannels. The channel **36** is the priority channel for reply communications from the gateways **16** to the meters as well as for priority or alarm communication between the meters and the gateway **16**. The priority channel is shown by reference numeral **36** and reference characters PR in FIG. **1**.

Referring now to FIG. **2**, thereshown is a schematic illustration of each of the channels and the operating characteristics of each. Although specific properties are shown for each of the communication channels, it should be understood that the properties for each of the channels could be modified while operating within the scope of the present disclosure.

The communication bandwidth **38** is the entire bandwidth used for the communication between the individual meters **12** and the gateways **16**. In the embodiment shown, the communication bandwidth **38** is 150 kHz. As described previously, the communication bandwidth **38** is divided into individual channels A-E as well as the priority channel **36**. Each of the channels **26-34** has a bandwidth of 25 kHz.

During initial setup of the communication system, a control unit contained in each of the individual meters **12** is programmed to communicate with the gateway over the default channel **26**. The meter **12** includes a transceiver in communication with the control unit to both send and receive messages using RF communication techniques. The control unit can be selectively programmed either locally or remotely using the RF communication. The control unit thus dictates the manner in which messages are transmitted from the meter **12**.

Default channel **26** has a communication rate of 8 kb/s such that meters are able to communicate a message to one or more of the gateways in approximately 107.6 ms. At such rate, the gateway can receive nine messages per second. As illustrated in row **40**, channel **26** is particularly desirable when the communication between the meter **12** and the gateway **16** has a low signal-to-noise ratio.

Communication channel **28** occupies the adjacent 25 kHz of bandwidth and has a different modulation technique, as shown in row **42**. Channel **28** has a data transfer rate of 16 kb/s such that each individual message is transmitted in approximately 56.7 ms. At such a rate, the gateway can receive

approximately eighteen messages per second. As can be understood in FIG. **2**, if a meter is communicating over channel B rather than channel A, the time required to relay each individual message is substantially decreased. However, due to this decreased transmission time, any noise contained in the signal will have a greater effect. Thus, channel B is more applicable to transmissions that have a mid-level signal-to-noise ratio.

Communication channel C occupies the next 25 kHz and can have either a data transmission rate of 16 or 24 kb/s. At such rate, each message is transmitted for approximately 40.8 ms such that twenty-four messages per second can be received by each gateway. Once again, since the time required for each message to be sent is reduced, transmissions over channel C are more susceptible to noise. Thus, channel C is utilized when the communication between the meter and the individual gateway has a higher signal-to-noise ratio as compared to channels A or B.

Channel D occupies the next 25 kHz and again transmits data at either 16 or 24 kb/s. When a meter is relaying information along channel D, each message takes approximately 25.5 ms to complete. Again, since the time required to complete the message is reduced, the messages are more susceptible to noise. Once again, channel D is useful for messages that have a slightly higher signal-to-noise ratio as compared to channel C.

Finally, channel E is useful for communications in which the communications have the highest signal-to-noise ratio. Communications occurring over channel E take place at up to 36 kb/s such that each individual message is relayed in 20.2 ms. In such communication, 49.5 messages per second can be received by the gateway. The high signal-to-noise requirement by channel E indicates that communications over channel E are particularly desirable for meters that are physically close to the gateway or where the communication between the meter and the gateway is relatively unobstructed.

The priority channel **36** shown in FIG. **1** is broken down into two sub-channels, illustrated by reference numerals **46** and **48**. The first sub-channel **46** is a reply channel used by each of the meters to reply to a polling request issued by any one of the gateways. The reply channel **46** occurs at a lower data transmission rate of 4 kb/s where each message takes approximately 215.2 ms to complete. Since the polling responses are used less frequently, the relatively long message duration is not as vital as with the other channels previously described.

The sub-channel **48** also occupies 12.5 kHz but instead uses a faster data transmission rate of 16 kb/s such that each message is received in 24.5 ms. Sub-channel **48** is utilized to relay alarm conditions and other urgent messages from the meter **12** to the gateway **16**.

As can be understood by the above description of the channels used to convey messages between the meters **12** and the gateways **16**, the selection of the individual channels moving to the right from channel **26** to the leftmost channel **34** decreases the amount of time required for each of the messages to be sent, which is generally desirable. However, due to this decreased time of transmission, the signal-to-noise ratio required to assure that messages are received correctly indicates that channel E should be utilized only with meters that have the highest signal-to-noise ratio while channel A should be utilized with those meters that transmit messages having a lower signal-to-noise ratio. The system of the present disclosure is configured to select over which channel communication should take place between each of the meters **12** and the gateways **16** in the manner to be described below.

Referring now to FIG. **3**, when the system is initially set up, the control unit in each of the individual meters is configured to communicate the meter data to a gateway over default channel A, as illustrated by step **50**. As described with reference to FIG. **2**, channel A is a 25 kHz communication channel that has the longest message duration. The longer message duration ensures that the communication channel A is particularly desirable for communicating messages that have a low signal-to-noise ratio. Since channel A is the most robust and can handle transmissions having a relatively low SNR, channel A is assigned to each meter as a default.

Once the individual meter has been positioned within the communication system **10**, the meter **12** transmits messages over the communication paths **20** shown in FIG. **1**. The messages transmitted by each individual meter **12** may be received by multiple gateways, as also illustrated in FIG. **1**. As shown in FIG. **3**, each of the individual meters sends messages to the gateways in step **52** and one or more gateways receive the messages as illustrated in step **54**.

When each gateway **16** receives a message, the gateway determines the signal-to-noise ratio for each message received from the meter. The signal-to-noise ratio is communicated along with the meter data to the data communication site **14** through the public WAN **22**. The signal-to-noise ratio determined in step **56** is determined for each message received from the plurality of meters at each of the gateways **16** receiving the message. The signal-to-noise ratio is a measurement defined as the ratio of the signal power to the noise power that is corrupting the signal. The higher the signal-to-noise ratio, the higher the power of the signal is relative to the noise contained within the signal. Thus, when the signal-to-noise ratio is high, messages can be transmitted over a shorter period of time since the signal receiver is less likely to receive a corrupted signal.

Referring back to FIG. **1**, when the data accumulation site **14** receives the data from each of the meters **12** through the gateway **16**, the data accumulation site **14** can determine which gateway **16** received a message from each meter and determine which gateway **16** receives the message with the highest signal-to-noise ratio. As an illustrative example, the leftmost meter **12** shown in FIG. **1** communicates to the two leftmost gateways **16**. Each gateway **16** relays the received message to the data accumulation site **14**. The data accumulation site **14** can then determine which of the two gateways that receive the message from the leftmost meter **12** receives the message with the highest signal-to-noise ratio.

In step **58**, the system selects the gateway **16** that has the highest signal-to-noise ratio for messages received from the meter **12**.

Once the system determines which gateway **16** has the highest signal-to-noise ratio in step **58**, the system can then average the signal-to-noise ratio over a defined period of time. The averaging of the signal-to-noise ratio over a period of time provides a more accurate signal-to-noise ratio calculation for the messages transmitted by the meters to the gateways.

Once the system selects the gateway with the highest signal-to-noise ratio, the system analyzes the signal-to-noise ratio for the data transmission from the meter to the gateway, as illustrated in step **60**. The average signal-to-noise ratio is compared to an upper and lower threshold for each of the channels **26**-**34** shown in FIG. **2**. Preferably, each of the channels **26**-**34** has a minimum threshold value and a maximum threshold value for the signal-to-noise ratio required for transmission over each of the channels. As previously described, since each of the channels has a decreasing mes-

sage duration, it is important that the proper channel be selected for each individual meter.

Once the signal-to-noise ratio values have been compared to the various thresholds for each individual channel, the system selects a desired channel as illustrated in step **62**. As previously described, the system attempts to select the channel having the lowest message duration based upon the signal-to-noise ratio calculated for communication from the meter to the gateway. Once the system selects the desired channel for the meter, the channel selection is communicated to the control unit of the meter. The desired channel is assigned to the meter in step **64**. After the new channel has been assigned, the system returns to step **52** and the control unit contained in each of the individual meters begin to send messages to the gateways on the newly assigned channel. This process continuously repeats such that should the properties of the meter change or additional interference be introduced between the meter and the gateway, the meter can be updated to transmit information over a different channel.

In the embodiment shown in FIG. **3**, it is contemplated that the comparison of the SNR to the threshold for each channel, as illustrated in step **60**, may occur at only a desired interval. As an example, step **60** may occur only once a day. Thus, a new channel would not be assigned to a meter more than one time a day to reduce the complexity of the system operation. Since the physical configuration of the meters and the interference positioned between the meters and the gateway will change infrequently, it has been found that changes to the channel assigned to a meter occurs in only less than 1% of the meters on a daily basis. However, the system operating in accordance with the present disclosure allows the configuration of each individual meter to be automatically adjusted should any changes occur in the interference between the meters and the gateways.

If the system determines in step **60** that the signal-to-noise ratio is below the lowest threshold for channel A shown in FIG. **2**, the system then determines that the individual meter is unable to communicate directly to a gateway **16**. In such situation, the control unit of each individual meter can then be configured to communicate with one of the intermediate meters **18** shown in FIG. **1**.

As described with reference to FIG. **3**, if the system determines that the signal-to-noise ratio of the communication of the meter to the most desirable gateway is greater than the threshold value for the current channel assigned to the meter, the system moves the meter to one of the channels to the left of the current channel shown in FIG. **2**. The movement of the assigned channel to the right in FIG. **2** increases the baud rate, decreases the message transmission time and thus enhances the operation of the system by moving meters to the most desirable channel. If the meter was previously assigned to communicate through an intermediate meter **18**, the meter may be reconfigured to communicate directly to one of the gateways **16**.

Alternatively, if the system determines in step **60** that the current channel assigned to the meter is above the signal-to-noise ratio for the meter, the system moves the assigned channel to the meter left with reference to FIG. **2** to decrease the baud rate and increase the message transmission time. If the meter is already in channel A, the system then reconfigures the meter into a "buddy" mode in which the meter communicate to one of the intermediate meters **18** rather than directly to the gateway **16**.

Strong Meter Case

FIG. **4** illustrates an implementation in which three representative meters are illustrated in a system having three towers, A, B and C. The transmission area for each meter is determined by the equation πR^2, where the radius R is the distance from the meter. Therefore, if all three of the towers A, B and C are within the transmission radius of the strong meter, then approximately 27 towers will be affected by some level of signal strength. Prior art systems reduce this effect by utilizing power control at the endpoint and attempting to normalize power received at any given tower (QUALCOMM). This uses up control channel bandwidth and in fact reduces signal redundancy at a distant tower when no data collision would have occurred.

The present disclosure avoids loss of the intended message during on-air collisions by continually monitoring receive power level, or the like, during the reception of a message. If a colliding message occurs before the initial message was complete and the colliding message had a signal level with sufficient C to I for demodulation, then the reserve 'aborts' the first message and attempts to demodulate the second. In one embodiment, two DSP demodulators will attempt to simultaneously demodulate the first and the second colliding messages and utilize the message CRC or convolution encoding of encryption to validate which message was successful.

Weak Meter Case

The weak meter will always be at a disadvantage to the strong and mid SNR meters which will always win the collisions due to higher C to I and abort. To normalize these statistics in the weak endpoint case, the endpoint with a weak SNR, even to their best server tower, is placed on a separate channel, where only other weak SNR meters compete. In an ALOHA system with no time reference, this will yield non-slotted performance, except in cases of collisions between endpoints which experience a common level of fading, 10-15 dB. If one signal is faded such to provide a useful C to I for the endpoint to demodulate, the abort feature can bring the ALOHA performance up to slotted, even without a timing signal.

Minimum channels used in this method are one low SNR and one high SNR. As described previously, it is contemplated that the data accumulation site **14** will optimize the endpoint configuration on a daily basis. Further, it is contemplated that even during the reconfiguration, less than 1% of the meters will be reconfigured based upon the change to the signal-to-noise ratio.

I claim:

1. A method of selecting a communication channel for each meter of a plurality of meters in a communication system including a plurality of gateways that each communicate to a back end server, the method comprising the steps of:

- defining a plurality of communication channels in a continuous sequence between a first communication channel and a last communication channel, wherein the plurality of communication channels have increasing transmission rates and decreasing message durations from the first communication channel to the last communication channel;
- initially assigning a default communication channel to each of the plurality of meters;
- relaying a plurality of messages from each of the meters along the default communication channel;
- determining the signal-to-noise ratio of the messages received at each of the gateways for each of the plurality of meters;
- selecting one of the plurality of communication channels for each of the meters to optimize the modulation rate and message duration based upon the highest signal-to-noise ratio at one of the gateways for the plurality of message sent by the plurality of meters; and

assigning the selected communication channel to each of the plurality of meters, wherein the communication channels are assigned to the plurality of meters such that the plurality of meters are distributed across all of the plurality of communication channels such that at least one of the plurality of meters is assigned to each of the plurality of communication channels,

where tri-band operation is used such that the number of channels assigned is three where a first channel is assigned only endpoints having signal to noise ratio (SNR) to its best link margin gateway is low, and where a second channel is assigned only endpoints having a SNR to its best link margin gateway is medium, and where a third channel is assigned only endpoints having a SNR to its best link margin gateway is high.

2. The method of claim **1** where the first, second and third SNR channels are assigned endpoint traffic in a manor to normalize the total on-time or duty cycle of traffic such that the traffic is evenly spread.

3. The method of claim **1** where the first, second and third SNR channels are assigned endpoint traffic in a manor to normalize the total on-time or duty cycle of traffic such that the traffic is maximized into the high channel since more messages can be transacted per unit time.

4. The method of claim **1** wherein the default communication channel has a default modulation rate and a default message duration.

5. The method of claim **1** wherein at least one of the plurality of communication channels is defined as a priority channel, wherein each of the plurality of meters selectively communicates over the priority channel in addition to the communication channel assigned to the meter.

6. The method of claim **5** wherein the priority channel includes both an alarm sub-channel and a reply sub-channel.

7. The method of claim **6** wherein alarm messages are relayed to each of the plurality of meters over the alarm sub-channel and replies are communicated from each of the plurality of meters over the reply sub-channel.

8. The method of claim **1** wherein the plurality of meters are distributed into each of the plurality of communication channels such that meters having similar signal-to-noise ratios are assigned to the same communication channel.

* * * * *

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Olson et al.

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(54) **AMR TRANSMITTER AND METHOD USING MULTIPLE RADIO MESSAGES**

(71) Applicant: **Badger Meter, Inc.**, Milwaukee, WI (US)

(72) Inventors: **John A. Olson**, Brookfield, WI (US); **Ronald D. Benson**, Colgate, WI (US)

(73) Assignee: **Badger Meter, Inc.**, Milwaukee, WI (US)

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(63) Continuation of application No. 12/489,590, filed on Jun. 23, 2009, now Pat. No. 8,878,690.

(51) **Int. Cl.**

G08B 23/00	(2006.01)
G08C 15/06	(2006.01)
G08B 21/00	(2006.01)
G01D 4/00	(2006.01)

(52) **U.S. Cl.**
CPC ***G01D 4/004*** (2013.01); ***G01D 4/006*** (2013.01); *Y02B 90/242* (2013.01); *Y02B 90/243* (2013.01); *Y04S 20/322* (2013.01); *Y04S 20/325* (2013.01)

(58) **Field of Classification Search**
CPC G01F 15/06; G01D 4/004; Y02B 90/243; Y02B 90/242
USPC 340/870.02
See application file for complete search history.

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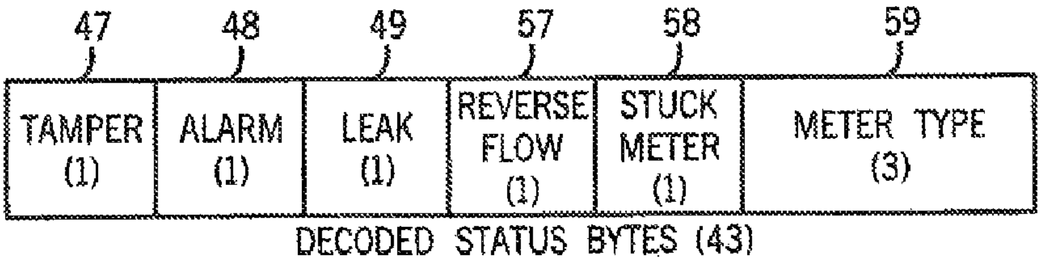
Primary Examiner — Firmin Backer
Assistant Examiner — Jerold Murphy
(74) *Attorney, Agent, or Firm* — Boyle Fredrickson, S.C.

(57) **ABSTRACT**

The invention provides a method and several types of devices for converting meter reading signals into data messages including a first message (**40**) having meter data (**44**) representing consumption of a utility, and meter diagnostic status data (**43**), and a second message (**60**) having meter reverse flow data (**63-65**) and meter diagnostic data (**66**) particular to an electronic flow meter, and receiving, said first message (**40**) and said second message (**60**) and converting first message and said second message to radio frequency signals (**25**) and transmitting said radio frequency signals (**25**) to a receiver (**22, 24**).

18 Claims, 8 Drawing Sheets



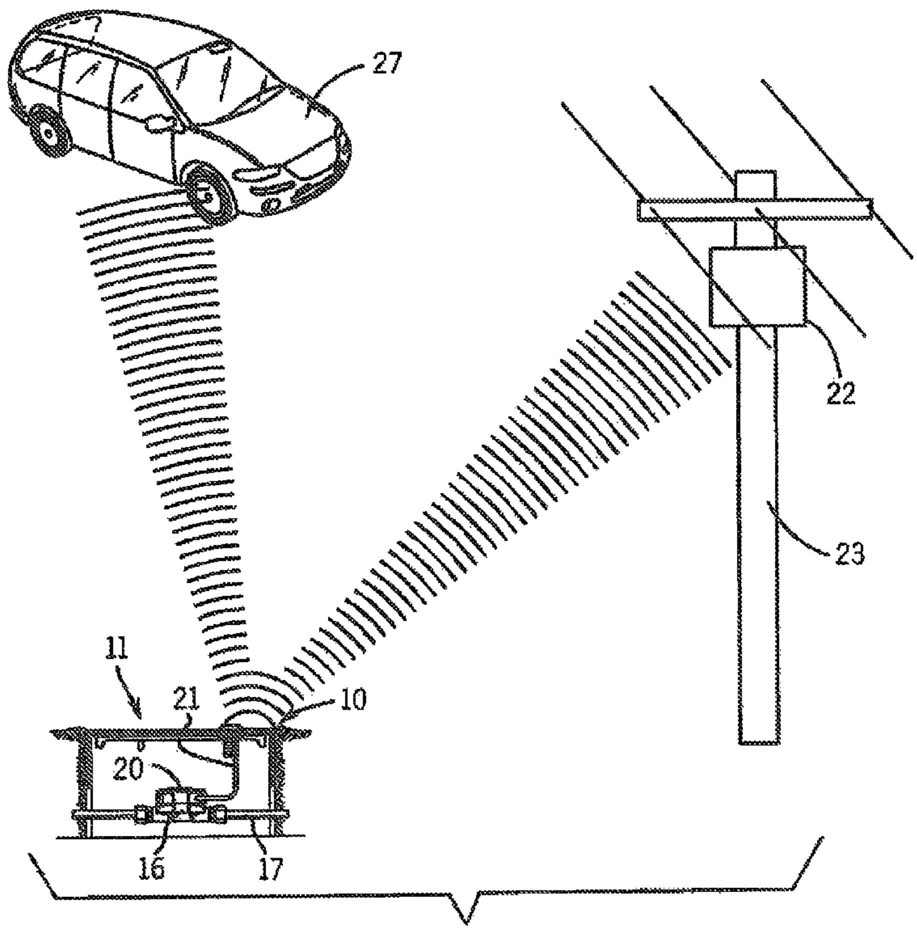


FIG. 1

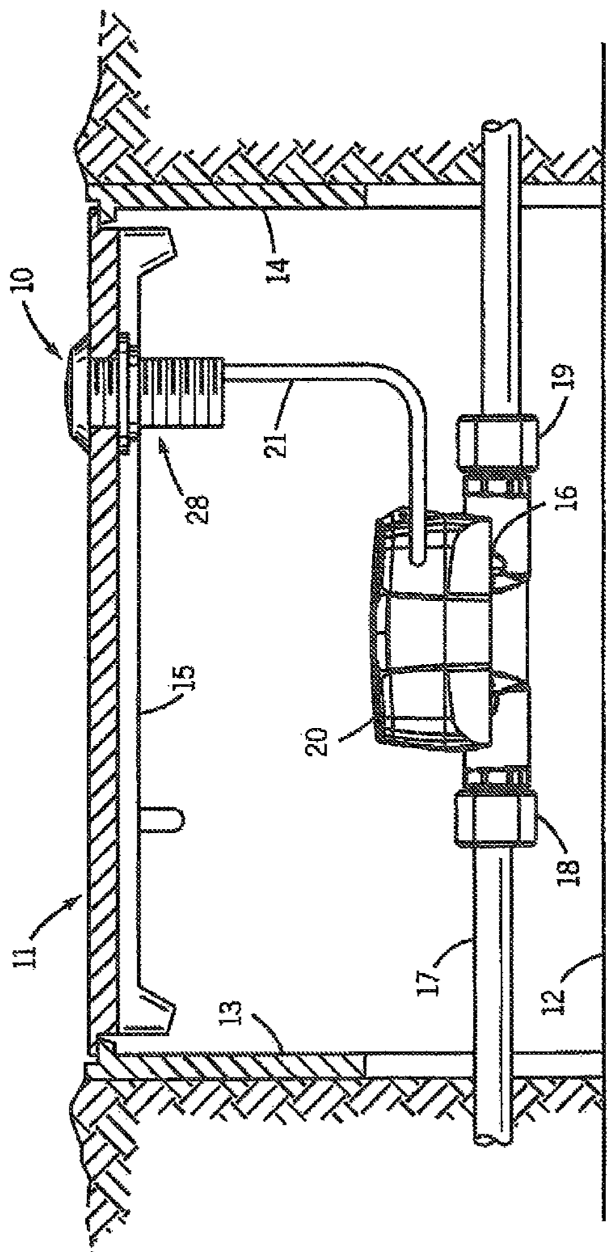


FIG. 2

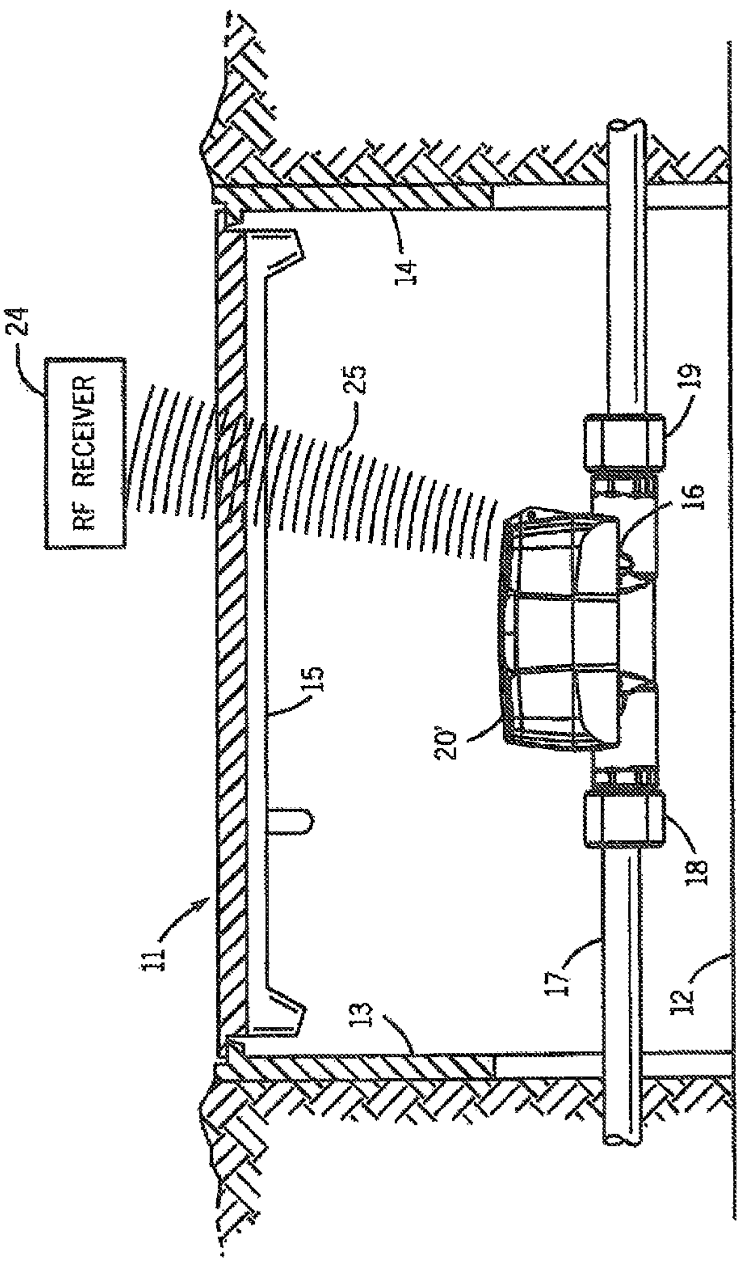


FIG. 3

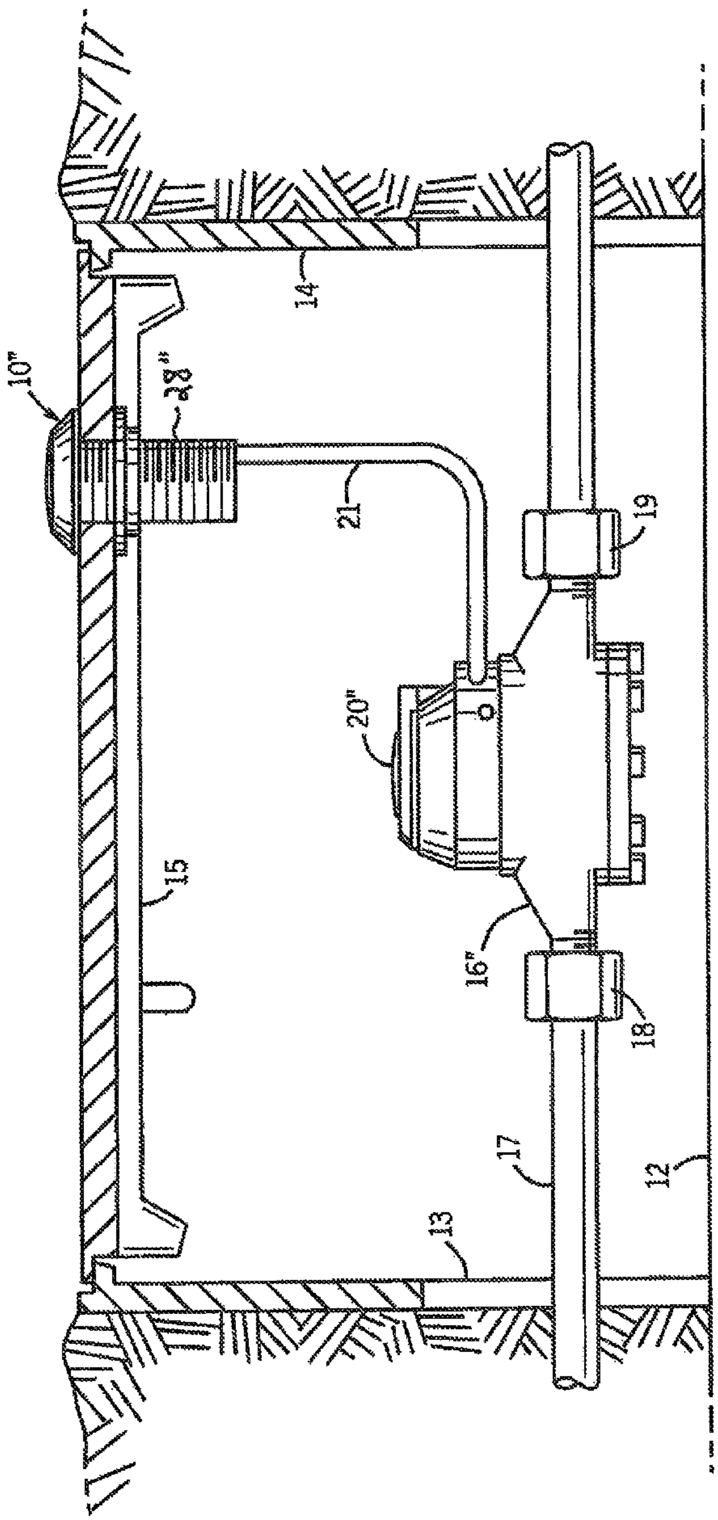


FIG. 4

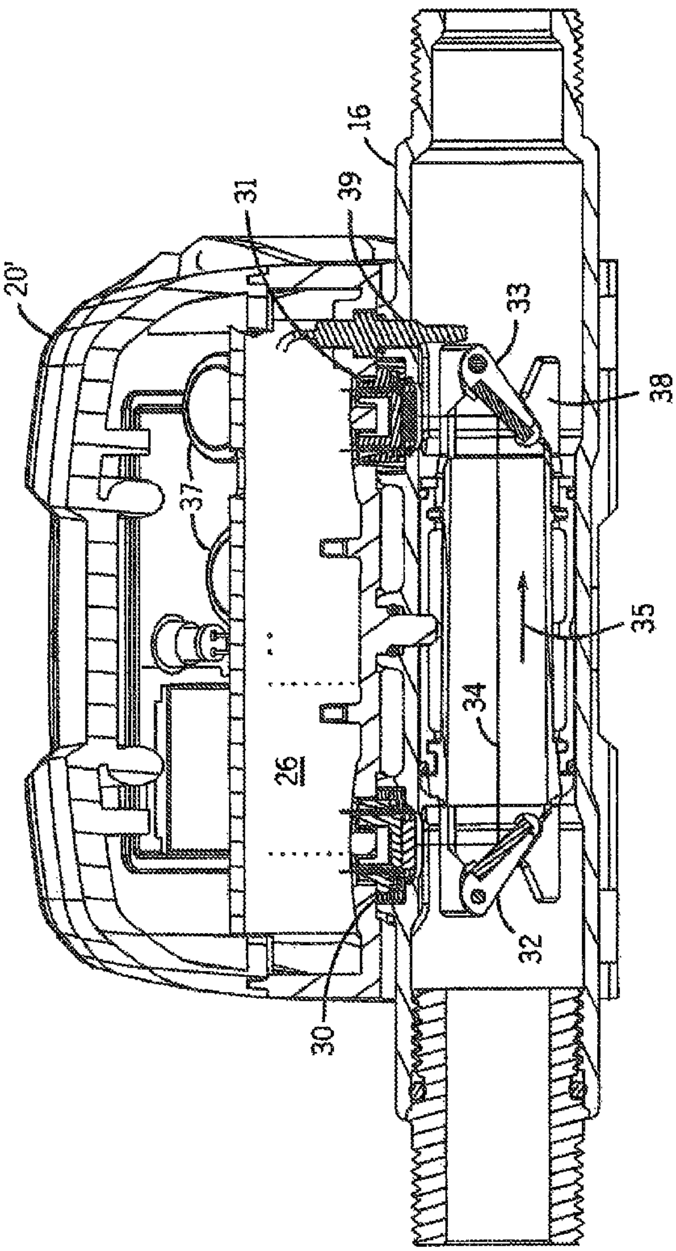


FIG. 5

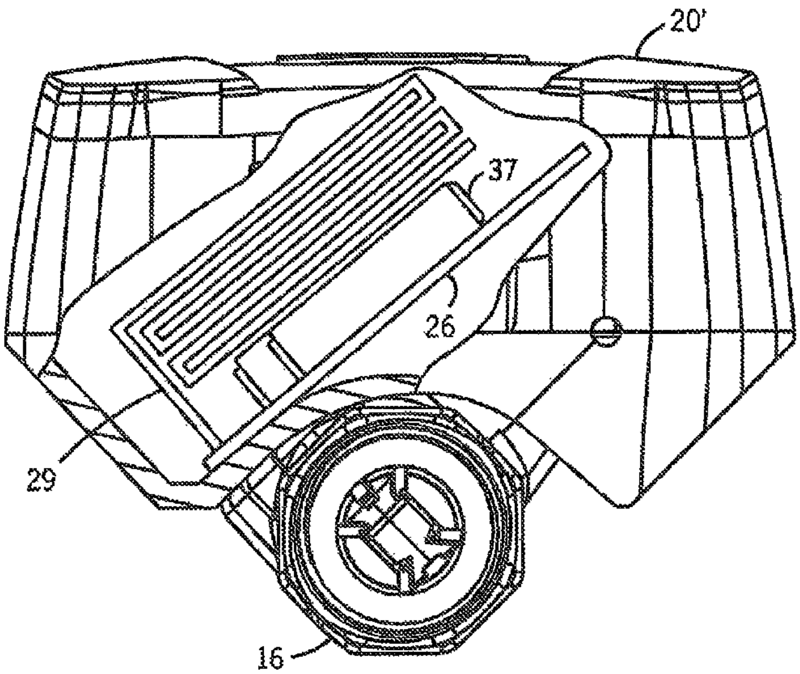


FIG. 6

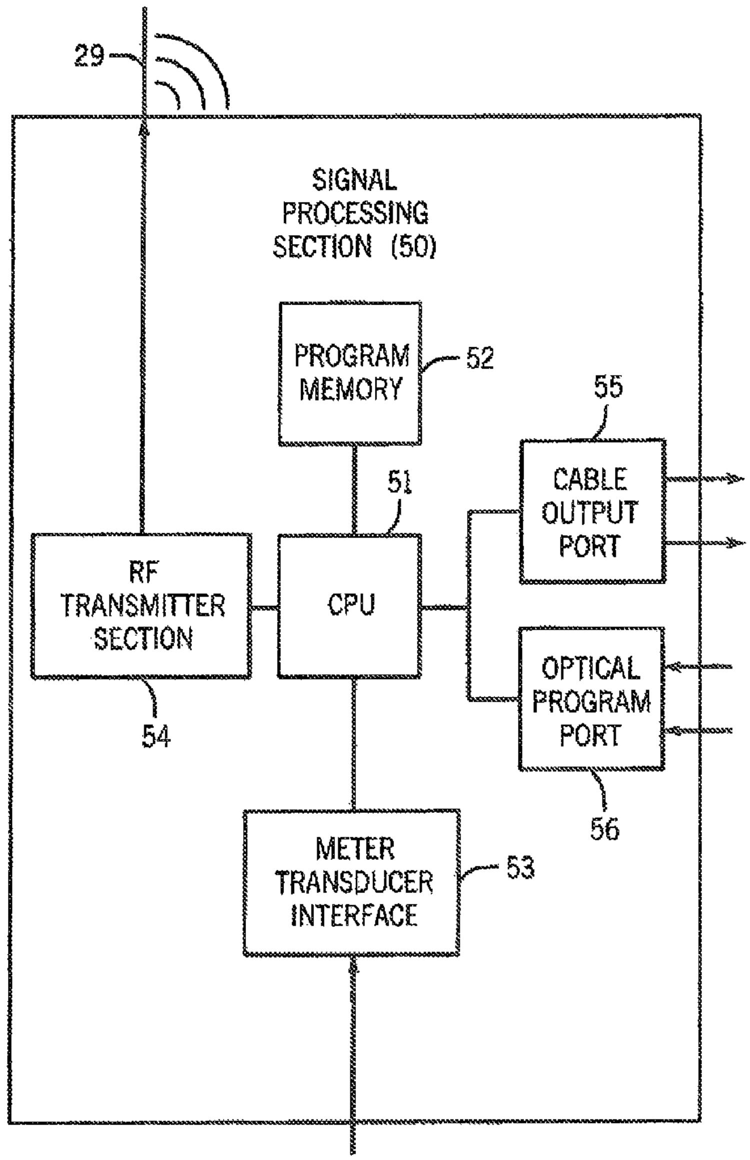

29
SIGNAL PROCESSING SECTION (50)
PROGRAM MEMORY
52
55
51
CABLE OUTPUT PORT
RF TRANSMITTER SECTION
CPU
OPTICAL PROGRAM PORT
54
56
METER TRANSDUCER INTERFACE
53

FIG. 7

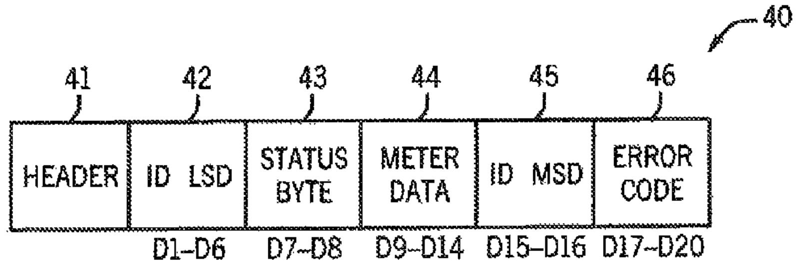


FIG. 8

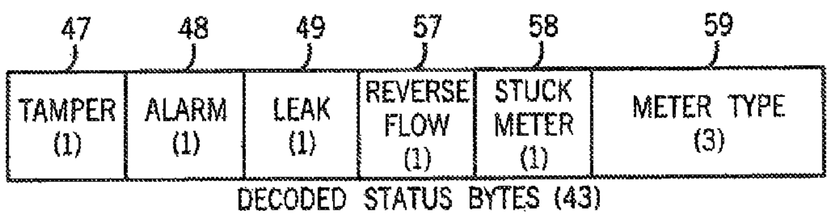


FIG. 9

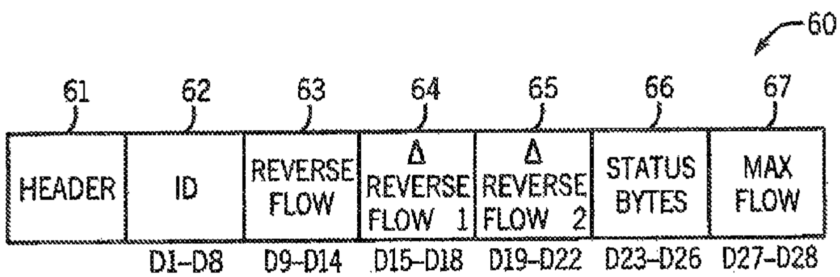


FIG. 10

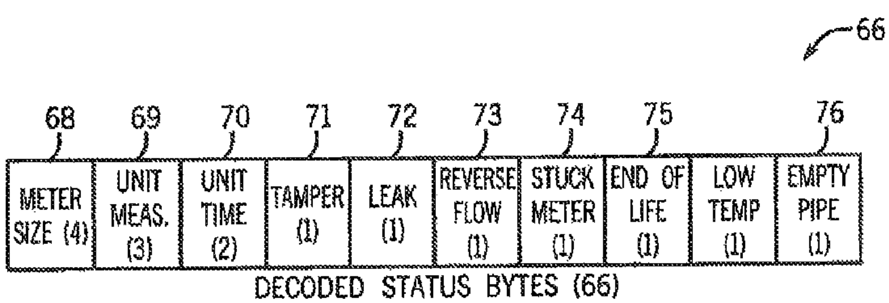


FIG. 11

AMR TRANSMITTER AND METHOD USING MULTIPLE RADIO MESSAGES

CROSS-REFERENCE TO RELATED APPLICATION

This application is a continuation, and claims the benefit of U.S. application Ser. No. 12/489,530, filed Jun. 23, 2009, the entirety of which is hereby incorporated by reference.

TECHNICAL FIELD

The present invention relates to automatic meter reading (AMR) systems that include an electronic meter or meter register and a network for collecting utility metering data.

DESCRIPTION OF THE BACKGROUND ART

Recently, electronic meter registers have begun to appear in utility metering applications. An example of a separate electronic meter register is disclosed in Olson, U.S. Pat. No. 6,611,769. An example of an electronic meter register integrated in one housing with a mechanical meter is disclosed in Lazar et al., U.S. Pat. No. 7,412,882.

Traditionally, ultrasonic and acoustic type meters have been used for measuring industrial and wastewater flows. Examples of such meters are disclosed in Lee, U.S. Pat. No. 3,935,735; Lee. et al., U.S. Pat. No. 4,052,896 and Vander Heyden et al., U.S. Pat. No. 4,633,713. Such meters depend on signals impinging upon particles in the flow stream, Doppler methods and time-of-travel characteristics to measure the flow. European Patent Publication 1493998A2, published Jun. 8, 2004, discloses an ultrasonic flow meter for utility usage.

The use of some types of electronic meters, such as ultrasonic types, fluidic oscillatory types and electromagnetic sensing meters, has been limited due to elements of cost. With advance in the design and construction of these devices, it may now be possible to meet marketplace pricing constraints.

Electronic meters have not previously been in widespread use in utility applications in the United States due to cost factors. As raw material costs and manufacturing costs are rapidly increasing at this time, there is a now a cost advantage to converting mechanical-based metering systems to electronic metering systems. Also, electronic meters are well-suited for use in AMR systems. Electronic meters provide greater accuracy than some other types of known utility meters. And, electronic meters are well adapted to flows with particles included.

Electronic meters and meter registers may be able to handle certain data that is particular to electronic meters such reverse flow data, empty pipe data and end-of-life data. This, however, requires improvements in network communication protocols to handle the additional data.

SUMMARY OF THE INVENTION

In one aspect, the invention relates to a method and circuitry for communicating metering data in a pair of related messages to a receiver. The first of two messages includes a transmitter ID number, utility consumption data, and diagnostic, data for conventional conditions such as, for example, a tamper indication, a leakage indication, and a stuck meter indication. A second message is provided to add reverse flow data and diagnostic data, particular to an electronic meter, such as an empty pipe indication, and an end of life indication.

In a further aspect of the invention, status data are added to the first message to indicate the presence of reverse flow data and diagnostic data, such as empty pipe, low temperature and end-of-life in the second message.

In a further aspect of this invention, the second message can be transmitted less frequently than the first message by an order of magnitude, or the interval can be extended for the purpose of conserving the life of one or more batteries.

The invention also provides diagnostic data and profiling data for reverse flow conditions over the last seven days and the last twenty-four (24) hours.

The invention is provided in three physical embodiments, one embodiment which fully integrates a meter, a meter register and a radio transmitter in one housing, and two other embodiments in which meter data is output through a data port from the meter register to a separate transmitter assembly, which can be mounted to a pit lid.

Other objects and advantages of the invention, besides those discussed above, will be apparent to those of ordinary skill in the art from the description of the preferred embodiments which follows. In the description, reference is made to the accompanying drawings, which form a part hereof, and which illustrate examples of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a perspective view of an AMR system, illustrating a mobile receiver in a drive-by vehicle and a fixed receiver for receiving transmissions from a transmitter associated with a utility meter;

FIG. **2** is a side view in elevation of a meter assembly and a separate transmitter assembly installed in a subsurface pit enclosure;

FIG. **3** is a side view in elevation of an integrated meter, meter transducer and transmitter assembly installed in a subsurface pit enclosure;

FIG. **4** is a side view in elevation of a conventional water meter with a meter register and a transmitter assembly of the present, invention installed in a subsurface pit enclosure;

FIG. **5** is a sectional view of the meter assembly of the present invention of FIG. **2**;

FIG. **6** is an end view of the meter assembly of FIG. **2** with parts of the housing broken away for a view of the interior;

FIG. **7** is a block diagram of a signal processing section within the meter of the present invention of FIG. **4**;

FIGS. **8-9** are data maps of a first message transmitted by the transmitter portion of FIGS. **2-4** to a receiver; and

FIGS. **10-11** are data maps of a second message transmitted by the transmitter portion of FIGS. **2-4** to a receiver.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring to FIGS. **1** and **2**, in this example, the invention is incorporated in a water meter assembly **16**, **20**, and a radio transmitter assembly **10** disposed in a subsurface pit enclosure **11** and connected by a cable **21**. The pit enclosure **11** is typically made of metal, concrete, plastic or other materials with a lid **15** which is removable to open the enclosure **11** for access. The pit enclosure **11** is located along the route of water supply pipe **17**. The housing assembly **16**, **20** includes a lower, tubular housing **16** for housing the water metering elements and for withstanding water pressure, which is connected in the water supply line **17** by coupling nuts **18** and **19** (FIG. **2**). An upper housing **20** for a water meter register, and in some other embodiments, a transmitter, is positioned on top of the lower housing **16**. This upper housing **20** is prefer-

ably made of plastic, such as polystryrene, ASA Luran or an equivalent non-metallic material. A visual display of a types known in the art would be seen from the top of the upper housing **20**. In recent years, the meter register has included a transducer for converting: i) mechanical movements, ii) movements of a magnet or iii) electrical meter signals to electrical signals of a type known in the art for signaling units of consumption of a utility.

As further seen in FIGS. **2** and **4**, in a "remote version" of the present, invention, a shielded cable **21** connects the electronics in the meter register housing **20, 20"** to a transmitter assembly **10, 10"**, which is housed in a tubular transmitter housing **28, 28"**, preferably of a plastic material, such as polystryrene, ASA Luran or an equivalent non-metallic material. The transmitter housing **28, 28"** hangs down from the pit lid **15** and includes its own battery, as is known in the art. The transducer electronics in the meter register housing **20, 20"** transmits electrical signals representing units of consumption of a utility to the transmitter assembly **10, 10"**, which incorporates meter data and other data in messages encoded for transmission through a radio network.

FIG. **2** provides a version in which the meter and meter-register are integrated, but where the transmitter assembly **10** is contained in a separate housing. FIG. **4** represents the traditional configuration of a separate meter register **20"** mounted on a water meter housing **16"** with a separate transmitter assembly **10"**.

In a fully "integrated version" of the invention seen in FIG. **3**, a housing **20'** encloses both meter register and transmitter formed on a circuit board **26** and an antenna **29** for transmitting signals directly through the pit lid **15** to a radio signal receiver **24**. In this version, the pit lid **15** is made of a non-RF-interference material, for example, plastic, concrete or other materials that will not significantly change the direction of, or attenuate, RF signals.

The transmitter assemblies **10, 10", 26** communicate via RF signals with a receiver **24** which can be a mobile receiver in a vehicle **27** seen in FIG. **1**. The transmitter assemblies **10, 10" 26** each transmit radio frequency signals encoded with messages and meter data, as will be further described below in relation to FIGS. **8-11**. The meter data is collected from various customer locations and transmitted to a central office for processing for billing purposes.

In the present invention, the transmitter assemblies **10, 10", 26** also communicate, via RF signals with a fixed receiver **22** installed on a utility pole **23** seen in FIG. **1**, within a range of up to one thousand feet of the transmitter unit **10**. The transmitter assembly **10, 10", 26** transmits electronic messages, including meter data, as will be further described below in relation to FIGS. **8-11**.

Referring to FIG. **5**, in the integrated meter, meter register and transmitter (FIG. **3** version), the meter housing **16** is made of brass or another suitable material, preferably lead-free, to withstand water pressures. Inside the housing **16** is a plastic metering insert **38** positioned in the conduit **16** and supporting two mirrors **32, 33** at minus forty-five degrees and plus forty-five degrees, respectively, relative to vertical. The assembly also includes two ultrasonic transducers **30, 31**, a temperature sensor **39**, a signal processing section, **50**, and one or more batteries **37**. A first ultrasonic signal will be transmitted through one of the transducers **30** downward, to reflect off one of the mirrors **32** at ninety degrees, to travel through the flow stream **35** as an ultrasonic signal parallel to the flow stream and the meter housing **16**, which is shaped like a pipe. The signal will then reflect off the second mirror **33** at ninety degrees and be detected by the second ultrasonic transducer **31** and converted to an input to the signal processing section **50** in FIG. **7**. A second signal is then transmitted in a reverse direction through second one of the transducers **31**, downward to reflect off the second one of the mirrors **33** at ninety degrees to travel through the flow stream **35** opposite the direction of flow **35** and parallel to the direction of flow and the conduit **16**. The signal will then reflect off the first-mentioned mirror **32** at ninety degrees and be detected by the first ultrasonic transducer **30** and input to the signal processing section **50** in FIG. **7**. A temperature sensor **39** is also positioned with one end projecting into the flow stream **35**.

Referring to FIG. **7**, the housing **20'** in FIGS. **3** and **5**, encloses an electrical signal processing section **50** typically formed on a circuit board **26** and including a microelectronic CPU **51** operating according to a control program, of program instructions stored in a program memory **52**, which may be internal to the CPU **51**. The memory **52** is flash memory that can be altered with a special programming unit, which communicates with the transmitter through an optical I/O data port **56**, preferably utilizing the IrDa (infrared frequency) protocol. Data profiling data for reverse flow is read through this optical I/O data port **56** as well. This can be stored in a non-volatile memory external to the CPU **51**.

As further seen in FIG. **7**, the CPU **51** receives signals from an ultrasonic transducer interface **53**. This section **53** can receive the ultrasonic signals **34** after conversion by the transducers **30, 31**, to eventually produce data signals at a logic level of power, such as 3.6 dc volts, for digital circuitry. The CPU **51** produces metering data in messages, which are converted to radio frequency (RF) signals by an RF transmitter section **54** that modulates signals for transmission. These signals can then be signaled directly through an antenna **29** (FIGS. **6** and **7**) to an RF receiver, represented generally by block **24** in FIG. **3**, provided that the pit lid **15** is not made of metal so as to interfere with the radio frequency signals. The message data contained in the RF transmissions is mapped in FIGS. **8-11**.

In the embodiments in FIGS. **2** and **4**, a meter transducer section (not illustrated) in the meter register housing **20, 20"** would transmit data representing units of utility consumption through a cable output port and through the cable **21**, to respective transmitter assemblies **10, 10"** seen in FIGS. **2** and **4** for conversion to RF signals and transmission to a radio receiver **24** seen in FIG. **1**. In these embodiments, the transmitter assemblies **10, 10"** would include a signal processing section of a type seen in FIG. **7**, including a CPU, a program memory, an RF transmitter section and an antenna to convert the meter data to radio frequency signals according to a message protocol. The information in the radio messages, as transmitted from the transmitter assemblies **10, 10"**, would be organized as illustrated in FIGS. **8-11**.

The radio signals can be transmitted from the AMR transmitter in several modes of operation, in a one-way AMR network. Although the invention is disclosed in one example, in a one-way network, the invention could also be applied in a two-way communication network, where each radio transmitter described herein would be included as one portion of a transceiver. Drive-by vehicles **27** (FIG. **1**) will be able to read the transmitter signal and collect meter readings. This type of system uses a battery for power and this mode of transmission provides long battery life using small batteries. This signal may be read by fixed receivers **22** provided they are not too far from the transmitter.

To reach fixed location receivers **22** (FIG. **1**), it is desirable to provide a transmission utilizing a higher power level than the prior art low power methods used for communicating with drive-by receivers. In the present invention, this is accomplished by sending out a frequency-hopping spread-spectrum

(FHSS) signal over twenty-five channels. Various time periods can be observed in sending out the two messages, and the second message may be sent out less frequently than the first message.

FIGS. **8**-**11** show the data in the two messages referred to more generally above. The messages contain data for implementing various alarm conditions, including a reverse flow alarm, a potential leak alarm, a stuck meter condition, (no usage for 30 days), a tamper alarm, an empty pipe alarm, a low temperature alarm and an end-of-life notification. The reverse flow alarm, the empty pipe condition and the end-of-life notification are conditions which are particularly related to electronic flow meters. The low temperature condition is a feature of the ultrasonic flow meter that is available, and is sensed with the addition of a temperature sensor **39** to the meter housing assembly **16**, **20** as seen in FIG. **4**.

As seen in FIG. **8**, the first message **40** includes a header **41** of forty-eight (48) bits, a data field and an error code field in the form of 120 bits comprising twenty (20) hexadecimal digits. The first six hexadecimal digits, D**1**-D**6**, provide digits of a transmitter identification number. The next two hexadecimal digits, D**7**-D**8**, provide status data **43** seen in more detail in FIG. **9**. This is followed by six hexadecimal digits, D**9**-D**14**, of meter data representing consumption of the utility by the customer. This is followed by two more hexadecimal digits, D**15**-D**16**, providing the most significant digits of a transmitter identification number. This is followed by four more hexadecimal digits, D**17**-D**20**, providing an error checking code, preferably a cyclic redundancy code (CRC).

Referring to FIG. **9**, the status byte **43** includes status bits indicating presence of alarm data in a following message for the tamper alarm **47**, other alarms **48** such as empty pipe, low temperature (3 degrees C. or below) or end-of-life, potential leak alarm **49** (no usage 24 hours), reverse flow alarm **57** or stuck meter (no usage) alarm **58**. The last three bits **59** indicate a meter encoder type, such as RTR, ADE or gas, which are types known from the commercial products of the assignee.

As seen in FIG. **10**, the second message **60** also includes a header **61** of forty-eight (48) bits, a data field and an error code field in the form of 136 bits comprising thirty-four (20) four-bit hexadecimal digits. The first eight hexadecimal digits, D**1**-D**8**, provide four bytes of a transmitter identification number. The next six hexadecimal digits, D**9**-D**14**, provide reverse flow data **63**. This is followed by four hexadecimal digits, D**15**-D**18**, of "Δ reverse flow" data **64** in the last twenty-four (24) hours. This is followed by four more hexadecimal digits, D**19**-D**22** providing of "Δ reverse flow" data **65** in the last seven (7) days. This is followed by four more four more hexadecimal digits, D**23**-D**26**, providing two bytes of status data **66** seen in more detail FIG. **11**. This is followed by two more hexadecimal digits, D**27**-D**28**, providing data for max flow rate and by four more hexadecimal digits D**29**-D**32** (not shown in FIG. **9**) providing an error checking-code, preferably a cyclic redundancy code (CRC).

FIG. **11** shows the details of the two status bytes **66** in which meter size is defined by four bits **68**, a unit of measure is defined by the next three bits **69**, units of time are defined by the next two bits **70**, and indicators are provided, for the following alarms: tamper **71**, leak **72**, reverse flow **73**, stuck meter **74** (no usage for 30 days), end-of-life **75** and low temperature **76**.

It should noted that the alarm status bits **47**-**49** and **57**-**58** in the first message in FIG. **8** indicate the presence of actual alarm data in the second message. It should now be apparent how the first message and second message contribute to increasing the diagnostic data available in the two messages due to the capabilities of an ultrasonic flow meter. This provides advantages in diagnosing operating-conditions, which have not been known before the invention.

This has been a description of the preferred embodiments, but it will be apparent to those of ordinary skill in the art that variations may be made in the details of these specific embodiments without departing from the scope and spirit of the present invention. For example, although the preferred embodiment uses ultrasonic signals to develop a meter reading, it will be apparent that the same messaging can be applied to fluidic oscillator type or electromagnetic type meters and that such variations are intended to be encompassed by the following claims, unless specifically excluded.

We claim:

1. Apparatus for use in transmitting radio messages in an automatic meter reading network, the apparatus comprising:

a processing circuit for converting meter reading signals into messages, including a first message having utility consumption data and a meter diagnostic status message indicating the presence of alarm data in a second message generated after the first message, the second message having meter reverse flow data and meter diagnostic data including the alarm data providing additional information related to the alarm data in the first message; and

transmitter circuitry configured for receiving said first message and said second message from the processing circuit, the transmitter circuitry converting said first message and said second message into radio frequency signals and transmitting said radio frequency signals to an external receiver.

2. The apparatus as recited in claim **1**, further comprising an electronic flow meter, the apparatus being housed in one housing assembly that can be installed in as pipe.

3. The apparatus as recited in claim **2**, wherein the electronic flow meter is more particularly an ultrasonic flow meter, and the assembly further comprises a low temperature sensor disposed in the flow stream and wherein the diagnostic data includes a low temperature event signal.

4. The apparatus as recited in claim **1**, further comprising an electronic flow meter and wherein the electronic flow meter and the processing circuit for converting meter reading signals into messages, are housed in a housing assembly that can be installed in a pipe, and wherein the transmitter circuitry is housed in a separate housing.

5. The apparatus as recited in claim **4**, wherein the electronic flow meter is more particularly an ultrasonic flow meter, and the assembly further comprises a low temperature sensor disposed in the flow stream and wherein the diagnostic data includes a low temperature event signal.

6. The apparatus of claim **1**, wherein the processing circuit and the transmitter circuitry are enclosed in a transmitter housing separate from a meter and a Meter register that provides signals representing units of utility consumption to the transmitter housing.

7. The apparatus as recited in claim **1**, wherein the diagnostic data includes at least one of: reverse flow data, empty pipe data and battery life data.

8. The apparatus as recited in claim **1**, wherein the diagnostic data includes reverse flow indicating reverse flow conditions over a last seven days and includes data indicating reverse flow conditions over a last twenty-four hours.

9. The apparatus as recited in claim **1**, wherein the second message is transmitted less frequently than the first message.

10. The apparatus as recited in claim **1**, wherein the first message and the second message are transmitted as frequency-hopping spread-spectrum signals.

11. The apparatus as recited in claim 1, wherein the first message and the message are transmitted by circuitry comprising a single transmitter.

12. The apparatus as recited in claim 1, further comprising an optical data port communicating with circuitry for converting meter reading signals, the optical data port providing access to an external device for reading reverse flow profiling data for a defined time period from the processing circuit.

13. A method of transmitting radio frequency signals representing utility metering data, the method comprising:

converting meter reading signals from a flow sensing device into messages, said messages including a first message having utility consumption data and a meter diagnostic status message indicating the presence of alarm data in a second message generated after the first message, the second message having meter reverse flow data and meter diagnostic data including the alarm data providing additional information related to the alarm data in the first message; and

receiving said first message and said second message and converting first message and said second message to radio frequency signals and transmitting said radio frequency signals to a receiver.

14. The method as recited in claim 13, wherein the electronic flow meter is more particularly an ultrasonic flow meter and the method further comprising sensing temperature in the flow stream and wherein the diagnostic data includes a low temperature event signal.

15. The method as recited in claim 13, wherein the diagnostic data includes at least one of reverse flow data, empty pipe data and battery life data.

16. The method as recited in claim 13, wherein the radio signals carrying the second message are transmitted less frequently than the radio signals carrying the first message to conserve power consumption in the utility meter interface device.

17. The method as recited in claim 13, wherein the second message is transmitted less frequently than the first message.

18. The method as recited in claim 13, wherein the meter reverse flow data includes data indicating reverse flow conditions over a last seven days and includes data indicating reverse flow conditions over a last twenty-four hours.

* * * * *

UNITED STATES PATENT AND TRADEMARK OFFICE

CERTIFICATE OF CORRECTION

PATENT NO.	: 9,417,093 B2	Page 1 of 1
APPLICATION NO.	: 14/531509	
DATED	: August 16, 2016	
INVENTOR(S)	: John A. Olson et al.	

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

In the Specification

Column 1, Lines 7-9 (under Cross Reference to Related Application): the phrase "U.S. application Ser. No. 12/489,530, filed Jun. 23, 2009" should read U.S. application Ser. No. 12/489,590, filed Jun. 23, 2009.

Signed and Sealed this
Eleventh Day of July, 2017

Joseph Matal

Joseph Matal
Performing the Functions and Duties of the
Under Secretary of Commerce for Intellectual Property and
Director of the United States Patent and Trademark Office

US009709421B2

(12) **United States Patent**
Blackwell et al.

(10) **Patent No.: US 9,709,421 B2**
(45) **Date of Patent: *Jul. 18, 2017**

(54) **METHOD AND SYSTEM FOR PROVIDING WEB-ENABLED CELLULAR ACCESS TO METER READING DATA**

(71) Applicant: **Badger Meter, Inc.**, Milwaukee, WI (US)

(72) Inventors: **Morrice D. Blackwell**, Mequon, WI (US); **Randall L. Schultz**, Fredonia, WI (US); **Yarum Locker**, Givat Shmuel (IL)

(73) Assignee: **Badger Meter, Inc.**, Milwaukee, WI (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

This patent is subject to a terminal disclaimer.

(21) Appl. No.: **14/171,272**

(22) Filed: **Feb. 3, 2014**

(65) **Prior Publication Data**

US 2014/0320304 A1 Oct. 30, 2014

Related U.S. Application Data

(63) Continuation of application No. 12/572,432, filed on Oct. 2, 2009, now Pat. No. 8,644,804.

(51) **Int. Cl.**
G01D 4/00 (2006.01)
H04L 29/08 (2006.01)

(52) **U.S. Cl.**
CPC ***G01D 4/002*** (2013.01); ***H04L 67/025*** (2013.01); ***H04L 67/125*** (2013.01); ***H04L 67/2828*** (2013.01); *Y02B 90/241* (2013.01); *Y02B 90/243* (2013.01); *Y02B 90/246* (2013.01); *Y04S 20/32* (2013.01); *Y04S 20/325* (2013.01); *Y04S 20/42* (2013.01)

(58) **Field of Classification Search**
CPC G01D 4/002; H04L 67/025
USPC 340/870.02, 870.03; 455/414.1
See application file for complete search history.

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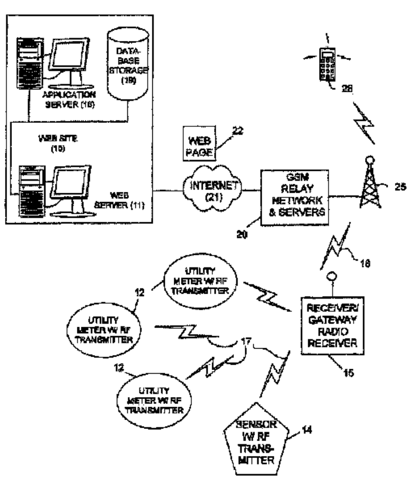
Primary Examiner — Nathan Mitchell
(74) *Attorney, Agent, or Firm* — Boyle Fredrickson, S.C.

(57) **ABSTRACT**

A method and a system for collection of meter readings from meter reading and transmitting devices (**12**, **14**) and for viewing on a web-enabled wireless communication device (**28**) comprises addressing at least one receiver (**15**) through the Internet (**21**) and obtaining a data file of meter data for a plurality of meter reading devices (**12**, **14**) that have previously communicated with the receiver (**15**). The receiver (**15**) can then re-transmit the meter data through a wide area network such as the Internet (**21**) to a web site (**10**) operated by an organization marketing AMR systems. The meter data is then accessed and displayed at a customer demonstration site using a handheld wireless smart phone (**28**) which receives a web page (**22**) that is reduced in size for transmission through the cellular network to the smart phone (**28**).

19 Claims, 2 Drawing Sheets



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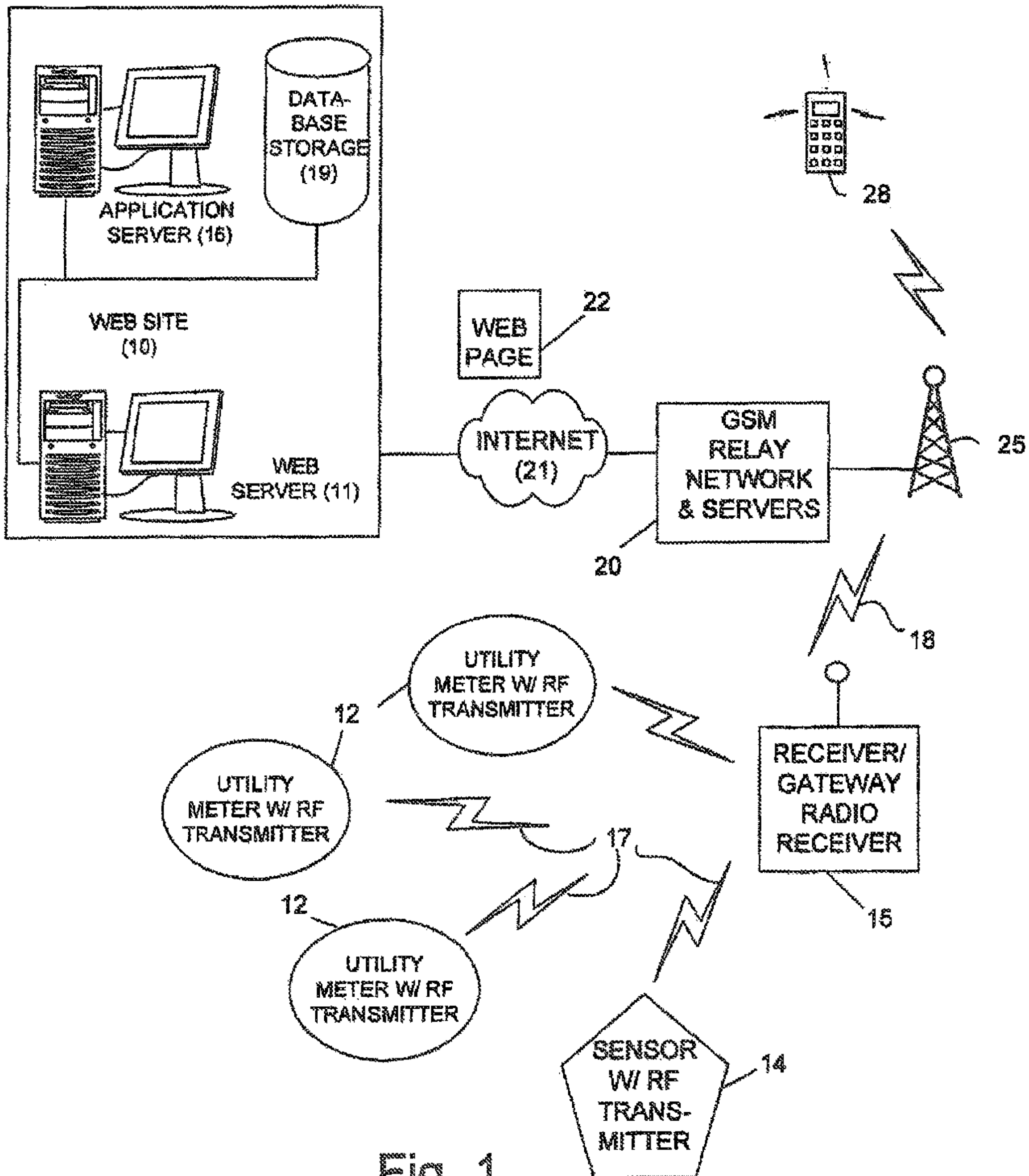
DATA-BASE STORAGE (19)
APPLICATION SERVER (16)
WEB SITE (10)
WEB SERVER (11)
WEB PAGE
22
INTERNET (21)
GSM RELAY NETWORK & SERVERS
20
28
25
18
UTILITY METER W/ RF TRANSMITTER
12
UTILITY METER W/ RF TRANSMITTER
12
UTILITY METER W/ RF TRANSMITTER
17
RECEIVER/ GATEWAY RADIO RECEIVER
15
SENSOR W/ RF TRANS-MITTER
14

Fig. 1

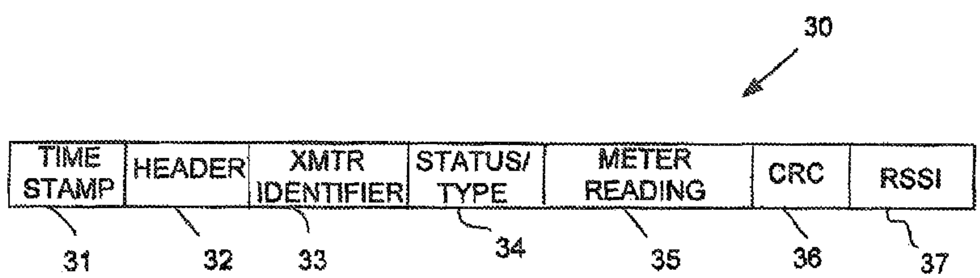
30
TIME STAMP
HEADER
XMTR IDENTIFIER
STATUS/ TYPE
METER READING
CRC
RSSI
31
32
33
34
35
36
37

Fig. 2

METHOD AND SYSTEM FOR PROVIDING WEB-ENABLED CELLULAR ACCESS TO METER READING DATA

This application is a continuation of U.S. application Ser. No. 12/572,432, filed Oct. 2, 2009, the disclosure of which is hereby incorporated by reference herein.

TECHNICAL FIELD

This invention relates to automatic meter reading (AMR) systems using radio transmitters and receivers for collecting meter data signals over a geographical area, such as a municipality or utility district.

DESCRIPTION OF THE BACKGROUND ART

Fixed network (non-mobile) AMR (automatic meter reading) systems typically involve meters equipped with radio transmitters operating in a local area network with radio receivers, often mounted on a rooftop or a utility pole. The receivers also sometimes operate as gateways, for collecting meter data from the transmitters and then transmitting the meter data through a second network to a central office. The meter data is transmitted from the receivers or gateways to the central office for processing into customer statements of account. Typically, there is at least a network communications computer and an applications computer at the central office of the local utility, although various systems at the collection end are possible and are known in the art.

In the prior art, installing an AMR system included the setting up of a central office data collection system and a database for the meter data.

In the marketing of AMR systems, it would be advantageous to demonstrate the collection of meter reading data before actual installation of the central office data collection system. Prospective customers could then see how the system would work prior to contracting for installation of a large system.

SUMMARY OF THE INVENTION

The invention provides a method and a system for collection of meter readings from meter reading and transmitting devices and for viewing meter data on a web-enabled wireless communication device.

The method comprises addressing at least one receiver through a wide area network, preferably the Internet, to obtain meter data from at least one and usually a plurality of meter reading devices that have previously communicated with the receiver. The receiver can then re-transmit the meter data to a web site operated by the organization marketing AMR systems. The data is then be accessed from a customer demonstration site, preferably using a wireless communication device.

The method and system of the present invention can run on a web site that can be reached through a GSM or other cellular network. The method of the invention further includes reading a file of meter data in the form of an HTML web page, which is then modified for viewing on a web-enabled handheld wireless communication device.

The wireless communication device is preferably a web-enabled wireless communication device, such as a Blackberry web-enabled cellular phone, another web-enabled cellular phone or personal digital assistant (PDA). In alternative embodiments, the web-enabled wireless communication device can also be a laptop with wireless Internet capability, but a handheld wireless processor-based device is considered advantageous and is strongly preferred for convenience and portability.

The invention provides a demonstration tool that can be operated at a customer demonstration site by a sales person as part of a customer presentation without requiring assistance from engineering personnel as practiced in the prior art. The use of a Web application on a web-enabled telephone simulates collection of data at a utility collection site. This will demonstrate the capabilities of the AMR-networked system prior to purchase by utility customers and installation at their premises.

Other objects and advantages of the invention, besides those discussed above, will be apparent to those of ordinary skill in the art from the description of the preferred embodiments which follows. In the description, reference is made to the accompanying drawings, which form a part hereof, and which illustrate examples of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a schematic of a fixed-network AMR system for collecting meter data from transmissions from meter data reading devices and making the data available through a web-enabled cellular device; and

FIG. **2** is a data map of data received from the meter reading devices.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring to FIG. **1**, a network gateway receiver **15** is installed on a roof top (not shown) or on a utility pole (not shown). In this preferred embodiment, the utility is water, however, in other embodiments the utility can be gas or electricity.

A plurality of meter reading devices **12** each include a utility meter, a transducer and an RF (radio frequency) transmitter. In this example, the units **12** can be meter reading and transmitting units commercially offered under the Orion® trademark or the Galaxy® trademark by the assignee of the present invention. These meter reading devices **12** transmit radio frequency (RF) signals **17** to the receiver **15** to form a local area wireless network. It should be understood that there is typically more than one receiver **15** in a network, although only one is illustrated in FIG. **1**. Sometimes the receiver **15** is also referred to as a "gateway" because it interfaces between the local area wireless network and another longer range network **21**. Alternatively, the meter reading devices **14** may be sensors for sensing other types of conditions at the utility meter or in supply links connected to the utility meters. These sensors may be connected to Orion® or Galaxy® radio transmitters to transmit status data to the receiver **15**.

The meter reading devices **12**, **14** read meter data and certain alarm/condition status data from the meters. As used herein, the term "meter data" should be understood to include either utility consumption data or condition status data, or both. Condition status data includes leak detection data, tamper data and shut-off valve data and other types of data concerning meter operation besides actual utility consumption data.

The devices **12**, **14** transmit data-encoded RF signals over low power RF frequencies either in the non FCC-licensed ISM (Industrial-Scientific-Medical) band from 902 MHz to 928 MHz or in the FCC-licensed frequencies such as 150-200 Mhz, 325 MHz, 433.92 MHz or from 450 to 470 MHz.

The meter data transmitters **12**, **14** transmit to an RF receiver **15**, which in this case is a Galaxy® receiver offered by the assignee of the present invention. The receiver **15** is provided with wireless capability to re-broadcast transmissions to a GSM cellular tower **25**, a GSM network **20** and the Internet **21** to a GSM-networked web site **10**. This web site **10** includes a web server **11** for handling communications in both directions through the Internet **21**, and an applications server **16** for handling the content of pages for communication and display through the Internet **21**. The applications server **16** also stores and accesses data in a database stored in a database storage unit **19**. The database stores a receiver network address, a list of transmitting devices **12**, **14** served by the receiver **15**, a history of readings for the transmitting devices **12**, **14** and a history of readings from the receiver **15**. It should be mentioned here that many architectures are available for web sites using additional servers and these are within the scope of the present invention.

The web site **10** will store the meter data in web pages **22** that can be accessed at an Internet Protocol (IP) addresses having the format XXX.YY.ZZZ, where X, Y and Z are individual numbers from "0" to "9" or preferably at a domain name/URL address of the form http://www.(name).(domain)/where "(name)" is the site identifier and "(domain)" is a domain such as .com or .(country).

These web pages can be accessed through a GSM relay network and servers **20** that can convert HTML pages to web pages of a type that can be displayed on the visual display portion of a wireless handheld device, such as a Blackberry™ smart phone, as disclosed in U.S. Pat. No. 7,302,637, issued Nov. 27, 2007, the disclosure of which is incorporated here by reference.

The web site **10** will have its own distinctive domain name or IP address. It can be maintained by the marketing organization or a hosted by a third party on behalf of the marketing organization.

An application program is provided on the handheld wireless device **28** to access the web site **10** and obtain a reduced size version of the web page **22** through the GSM relay network and servers **20**.

When accessed by a user of the handheld device **28**, a log-in screen will appear prompting the user to enter a user name and a password. After logging in, the user will have an option to select a "Monitor mode or a Data View" mode. A search screen will also be available to allow the user to find the data for a specific transmitter. The web site **10** is addressed and a web page **22** of data is transmitted from the web site **10** to the web-enabled wireless device **28** through the Internet **21** and is converted to a reduced size web page as the web page **22** is transferred through the GSM relay network and servers **20**. On the handheld device **28**, a reduced size "Monitor" web page **22** will display the last transmissions that were received by the receiver/gateway **15** from the meter/transmitters **12**. The data displayed on the "Monitor" web page will include the transmitter number, the time of reception and an indication of signal strength (by a graphic representation of the RSSI). By selecting a line on the screen display of the web-enabled wireless device, the user can cause a display of a history of daily transmissions received from a specific transmitter.

The data is preferably displayed in a WAP format supported by web-enabled smart phone devices such as a Blackberry™ smart phone. Each line of data contains data received from one of the transmitters. FIG. 2 shows a map of each line of data **30** in a web page **22**. There is a first item of data **31** which is a time stamp for the individual meter reading device **12**, **14**. Next, there is a header **32**. This is followed by an item of data **33** representing the identifier, such as a serial number of the transmitter which corresponds to each meter reading device **12**, **14**. Next, there is a status or type item of data **34** which identifies one of several types meter reading devices **12**, such as an RTR® pulse register/transmitter type, an ADE® digital encoder type, or gas meter registers, or other designations for completely electronic registers. This is followed by the actual meter data or status condition data, as represented by item **35**. This is followed by a CRC item of data **36**, which is a cyclic redundancy code or error checking code computed from the data earlier in line of data. Finally, a radio signal strength indicator (RSSI) item of data **37** is provided from each meter reading device **12**, **14** for radio network diagnostics purposes.

As seen from the above description, the invention provides for easier demonstration of the data collection abilities of an AMR system on a handheld wireless processor-based device, thereby saving labor and installation cost and providing ease of use to the marketing organization and the utility customer.

This has been a description of the preferred embodiments, but it will be apparent to those of ordinary skill in the art that variations may be made in the details of these specific embodiments without departing from the scope and spirit of the present invention, and that such variations are intended to be encompassed by the following claims.

We claim:

1. A method for collection of meter data through a wide area network from at least one receiver communicating in a local network with at least one meter reading device in a geographic area, the method comprising:

receiving meter data generated by a utility meter and provided to a meter reading device, the meter data including both utility consumption data readings and condition status data generated by the utility meter, through the wide area network at a web site from a receiver that received the meter data from the meter reading device;

storing the meter data at the web site; and

accessing the meter data at the web site using a wireless communication device and displaying the meter data on a display portion of the wireless communication device, wherein the condition status data includes at least one of leak detection data, tamper data, radio signal strength, and shut-off valve data.

2. The method of claim **1**, wherein the meter data is accessed by an application program on the wireless communication device that displays the meter data as a reduced size web page.

3. The method of claim **2**, wherein the wireless communication is a handheld web-enabled phone device.

4. The method of claim **3**, wherein the handheld web-enabled phone device communicates through a GSM cellular network.

5. The method of claim **2**, wherein the meter data is received at the web site as an HTML web page and is stored at the web site.

6. The method of claim **5**, wherein the wide area network is the Internet.

7. The method of claim **1**, wherein the meter reading devices include devices for reading condition status data related to a meter or to supply links connected to the meter, and wherein the meter data includes condition status data.

8. A system for displaying meter reading data collected from at least one reading device in a geographic area, the system comprising:

a computer server implementing a web site for receiving and storing a data file through a wide area network from the at least one receiver that includes meter reading data, including both utility consumption data readings from the utility meter and condition status data, from a plurality of meter reading devices; and

a web-enabled cellular phone executing an application program for the web-enabled cellular phone for displaying condition status data and utility consumption data readings communicated from the web site accessible through a cellular network, wherein the condition status data includes at least one of leak detection data, tamper data, radio signal strength, and shut-off valve data.

9. The system of claim **8**, wherein the application program displays the meter data as a reduced size web page on a display portion of the web-enabled cellular phone.

10. The system of claim **8**, wherein web-enabled cellular phone communicates through a GSM cellular network.

11. The system of claim **8**, wherein the meter data is received at the web site as an HTML web page and is stored at the web site.

12. The system of claim **11**, wherein the wide area network is the Internet.

13. The system of claim **8**, wherein the meter reading devices include devices for reading condition status data related to a meter or to supply links connected to the meter, and wherein the meter data includes condition status data.

14. A method for collection of meter data through a wide area network from at least one receiver communicating in a local network with at least one meter reading device in a geographic area, the method comprising:

receiving data through the wide area network at a web site from the at least one receiver that includes meter data generated by a utility meter and provided via a meter reading device to the at least one receiver, the meter data including both utility consumption data readings and condition status data generated by the utility meter;

receiving a request to display the meter data at the web site from a wireless communication device; and

transmitting the meter data for display on a display portion of the wireless communication device, wherein the utility consumption data readings are meter readings for at least one meter reading device that have been transmitted at a defined time interval,

wherein receiving a request to display the meter data at the web site from a wireless communication device includes selection of a link displayed on a web page specific to the at least one meter reading device.

15. The method of claim **14**, wherein the meter data is displayed on the display portion as a reduced size web page.

16. A method for collection of meter data through a wide area network from at least one receiver communicating in a local network with at least one meter reading device in a geographic area, the method comprising:

receiving data through the wide area network at a web site from the receiver that includes meter data from at least one meter reading device;

receiving a request to display the meter data at the web site from a wireless communication device; and

transmitting the meter data for display on a display portion of the wireless communication device, wherein the meter data includes a plurality of meter readings for at least one meter reading device that have been transmitted at a defined time interval, wherein the meter data includes an indication of signal strength.

17. The method of claim **16**, wherein the indication of signal strength includes an indication of signal strength for each defined time interval.

18. The method of claim **17**, wherein the defined time interval is daily.

19. A method for collection of meter data through a wide area network from at least one receiver communicating in a local network with at least one meter reading device in a geographic area, the method comprising:

receiving data through the wide area network at a web site from the receiver that includes meter data generated by a utility meter and provided via a meter reading device to the at least one receiver, the meter data including both utility consumption data readings and condition status data generated by the utility meter;

receiving a request to display the meter data at the web site from a wireless communication device; and

transmitting the meter data for display on a display portion of the wireless communication device, wherein the utility consumption data readings are meter readings for at least one meter reading device that have been transmitted at a defined time interval,

wherein the at least one meter reading device includes a least one device for reading condition status data related to a meter or to supply links connected to the meter, and wherein the meter data includes condition status data.

* * * * *

US008269651B2

(12) **United States Patent**
Zigdon et al.

(10) **Patent No.: US 8,269,651 B2**
(45) **Date of Patent: Sep. 18, 2012**

(54) **MODULAR WIRELESS FIXED NETWORK FOR WIDE-AREA METERING DATA COLLECTION AND METER MODULE APPARATUS**

(75) Inventors: **Shimon Zigdon**, Netanya (IL); **Carmel Heth**, Grapevine, TX (US)

(73) Assignee: **Sensus USA Inc.**, Raleigh, NC (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 96 days.

(21) Appl. No.: **11/354,252**

(22) Filed: **Feb. 15, 2006**

(65) **Prior Publication Data**

US 2006/0244631 A1 Nov. 2, 2006

Related U.S. Application Data

(63) Continuation of application No. 10/199,108, filed on Jul. 22, 2002, now Pat. No. 7,012,546, which is a continuation-in-part of application No. 09/950,623, filed on Sep. 13, 2001, now Pat. No. 7,009,530.

(51) **Int. Cl.**
G08C 19/04 (2006.01)

(52) **U.S. Cl.** **340/870.11**; 340/870.01; 340/870.02; 370/310; 702/57

(58) **Field of Classification Search** 340/870.02, 340/870.01, 870.07; 370/395.31, 401, 310, 370/315; 235/435, 439, 440, 446; 700/22, 700/266, 90, 275, 286, 291; 702/1, 24, 45, 702/55, 57–62, 85, 98–100, 104, 128–126
See application file for complete search history.

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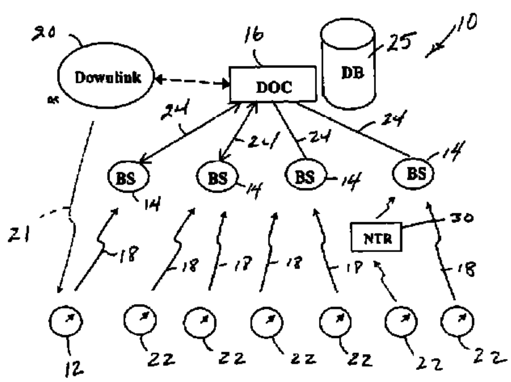
Primary Examiner — George Bugg
Assistant Examiner — Franklin Balseca
(74) *Attorney, Agent, or Firm* — Oblon, Spivak, McClelland, Maier & Neustadt, L.L.P.

(57) **ABSTRACT**

A one-way direct sequence spread spectrum (DSSS) communications wide-area network is the data collection channel (uplink) of an automatic meter reading (AMR) system, and a paging network, or other suitable communication channel is the optional forward (downlink) channel. The communications network may include one-way meter modules (transmitters) each communicatively coupled to a corresponding electric, gas or water utility meter, and may include two-way meter modules (transceivers) each coupled to such a corresponding utility meter. The meter modules monitor, store, encode and periodically transmit metering data via radio signals (air messages) in an appropriate RF channel. Metering data air messages are collected by a network of receiver Base Stations (BS) and forwarded to a Data Operations Center (DOC), which acts as a metering data gateway. The reception range of each base station is typically over 5 miles in urban areas, allowing sparse infrastructure deployment for a wide variety of metering data collection applications.

25 Claims, 16 Drawing Sheets



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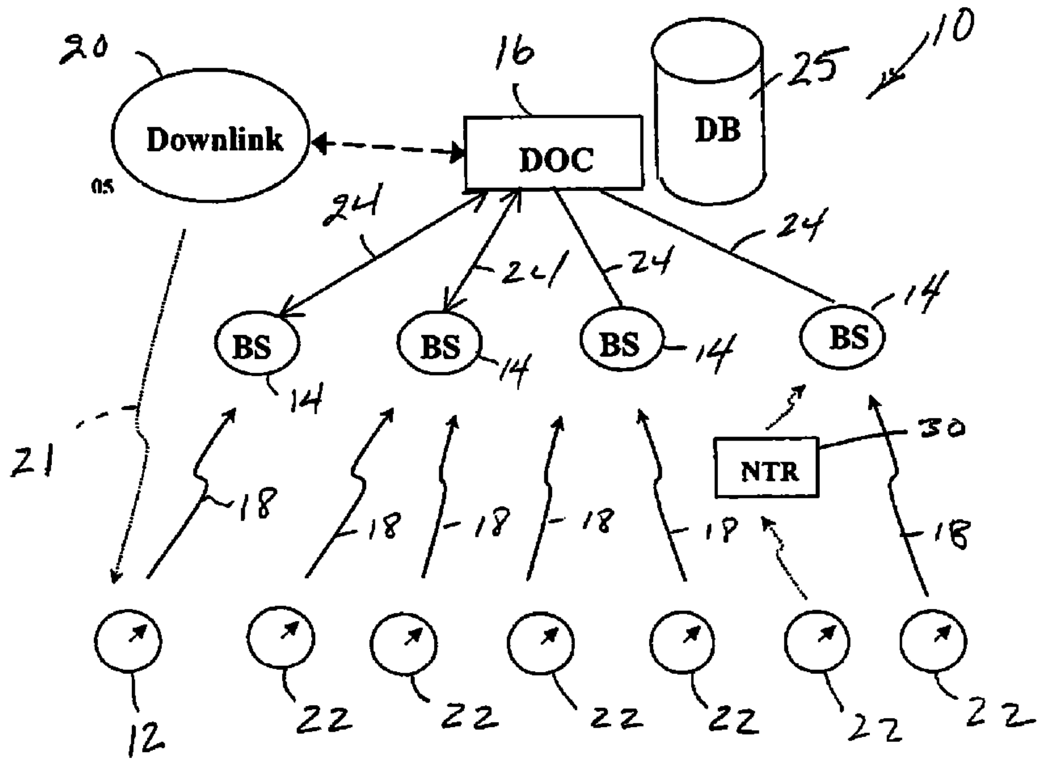
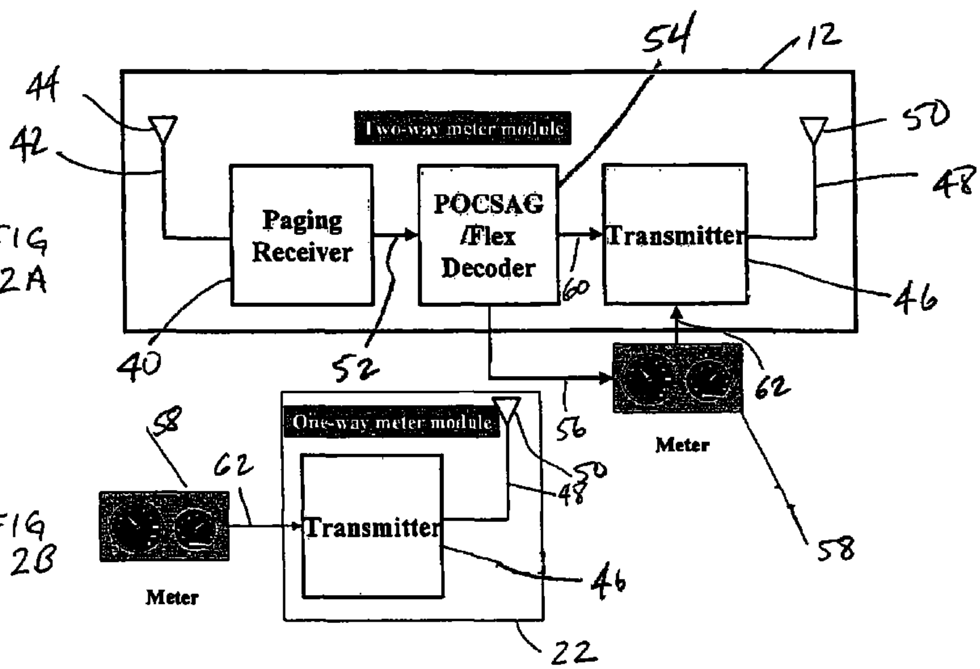

20
Downlink
05
16
DOC
DB
25
10
24
24
24
24
BS
BS
BS
BS
14
14
14
14
21
18
18
18
18
18
18
NTR
30
12
22
22
22
22
22
22

Figure 1

FIG 2A

FIG 2B


Two-way meter module
Paging Receiver
POCSAG /Flex Decoder
Transmitter
Meter
One-way meter module
Transmitter
Meter
44
42
40
52
54
12
50
48
46
60
56
62
58
22

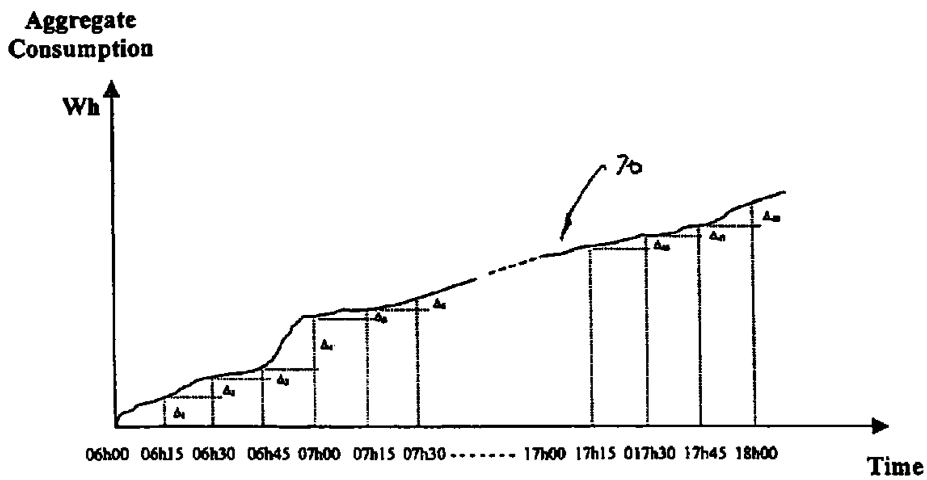
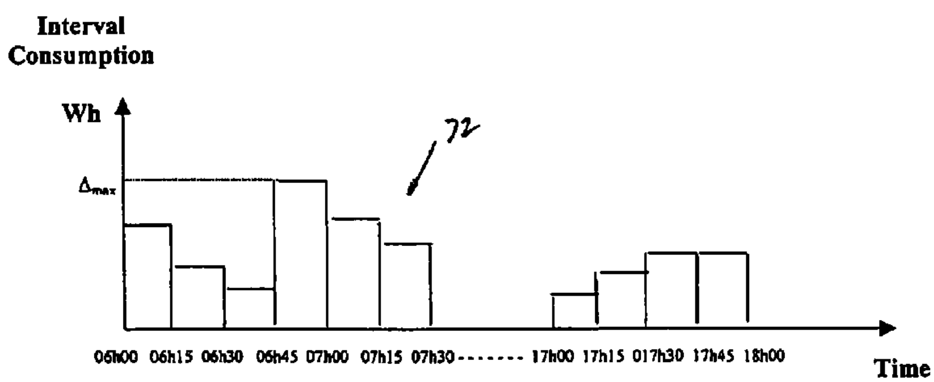


Figure 3A



6-10	600	300	200	800	600	500	200	100	0	0	0	100	100	200	0	0
10-14	0	0	0	0	0	0	0	0	0	0	900	1100	800	800	800	700
14-18	700	700	1000	900	300	400	0	100	100	600	800	1100	1600	1800	1000	1200

Figure 3B

Table 1:

Two-Bit Code	Wh Consumption
00	0
01	100
10	200
11	300

Table 2:

Two-Bit Code	Wh Consumption
00	0
01	100
10	300
11	600

Table 3:

Two-Bit Code	Wh Consumption
00	0
01	200
10	500
11	1000

Table 4:

Two-Bit Code	Wh Consumption
00	0
01	400
10	1000
11	1800

Figure 4

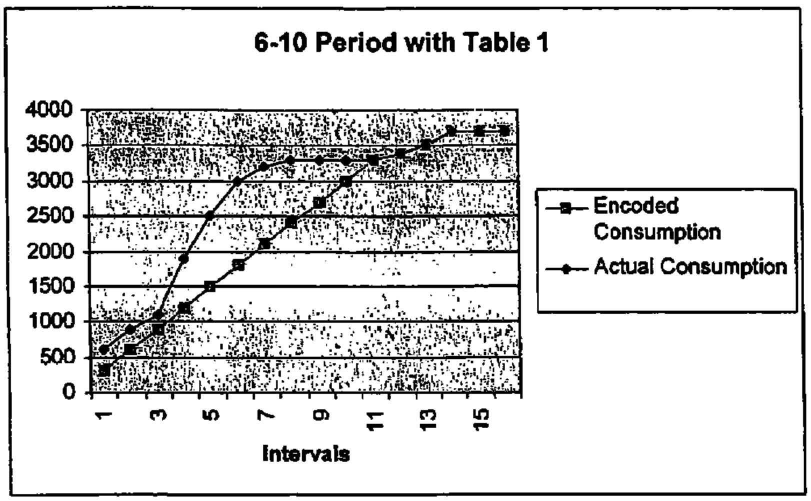


Figure 5A

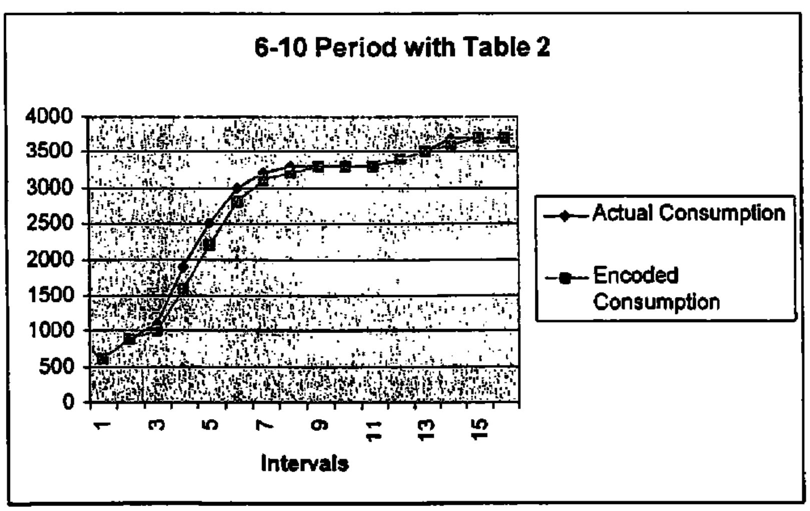


Figure 5B

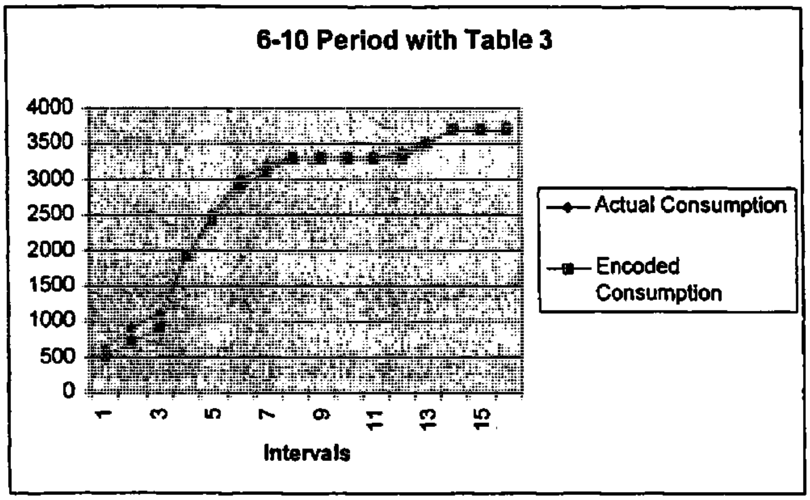


Figure 5C

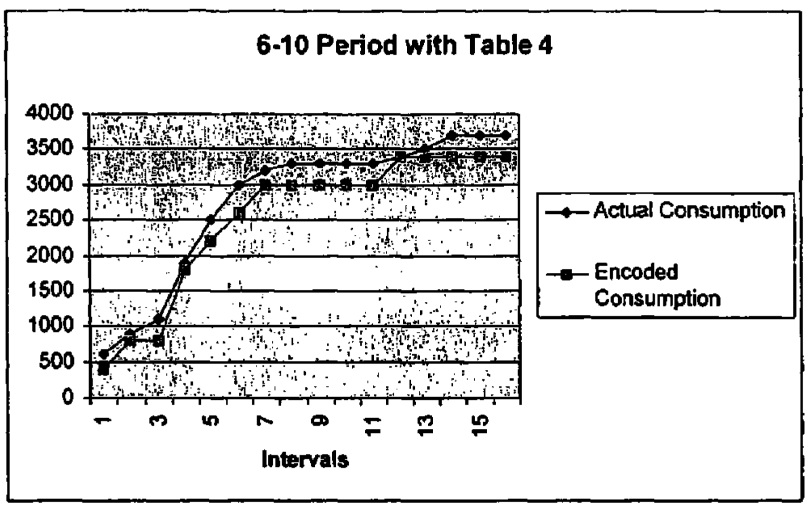


Figure 5D

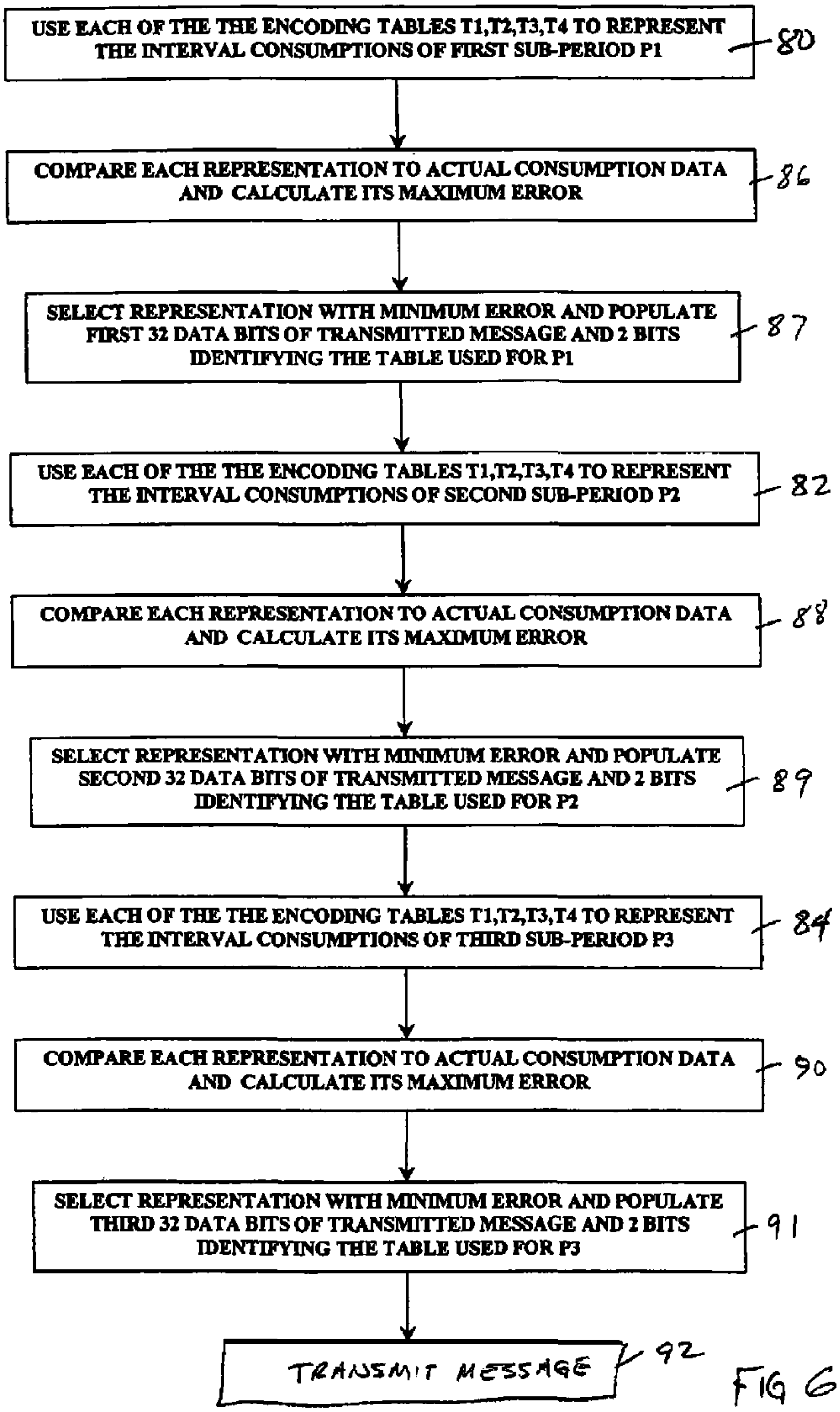

USE EACH OF THE THE ENCODING TABLES T1,T2,T3,T4 TO REPRESENT THE INTERVAL CONSUMPTIONS OF FIRST SUB-PERIOD P1
80
COMPARE EACH REPRESENTATION TO ACTUAL CONSUMPTION DATA AND CALCULATE ITS MAXIMUM ERROR
86
SELECT REPRESENTATION WITH MINIMUM ERROR AND POPULATE FIRST 32 DATA BITS OF TRANSMITTED MESSAGE AND 2 BITS IDENTIFYING THE TABLE USED FOR P1
87
USE EACH OF THE THE ENCODING TABLES T1,T2,T3,T4 TO REPRESENT THE INTERVAL CONSUMPTIONS OF SECOND SUB-PERIOD P2
82
COMPARE EACH REPRESENTATION TO ACTUAL CONSUMPTION DATA AND CALCULATE ITS MAXIMUM ERROR
88
SELECT REPRESENTATION WITH MINIMUM ERROR AND POPULATE SECOND 32 DATA BITS OF TRANSMITTED MESSAGE AND 2 BITS IDENTIFYING THE TABLE USED FOR P2
89
USE EACH OF THE THE ENCODING TABLES T1,T2,T3,T4 TO REPRESENT THE INTERVAL CONSUMPTIONS OF THIRD SUB-PERIOD P3
84
COMPARE EACH REPRESENTATION TO ACTUAL CONSUMPTION DATA AND CALCULATE ITS MAXIMUM ERROR
90
SELECT REPRESENTATION WITH MINIMUM ERROR AND POPULATE THIRD 32 DATA BITS OF TRANSMITTED MESSAGE AND 2 BITS IDENTIFYING THE TABLE USED FOR P3
91
TRANSMIT MESSAGE
92

FIG 6

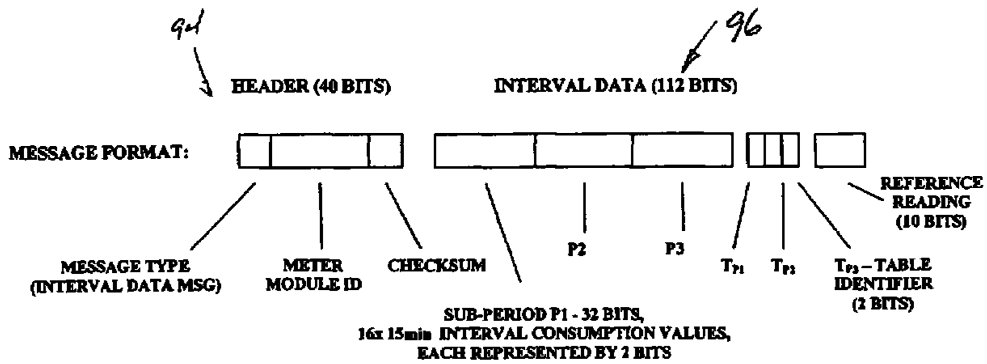

94
HEADER (40 BITS)
96
INTERVAL DATA (112 BITS)
MESSAGE FORMAT:
REFERENCE READING (10 BITS)
MESSAGE TYPE (INTERVAL DATA MSG)
METER MODULE ID
CHECKSUM
P2
P3
T_{P1}
T_{P2}
T_{P3} – TABLE IDENTIFIER (2 BITS)
SUB-PERIOD P1 - 32 BITS, 16x 15min INTERVAL CONSUMPTION VALUES, EACH REPRESENTED BY 2 BITS

FIG 7

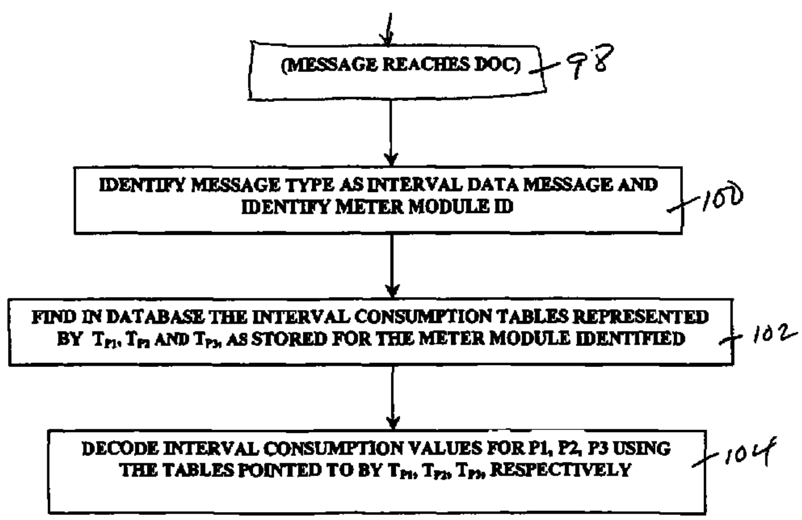
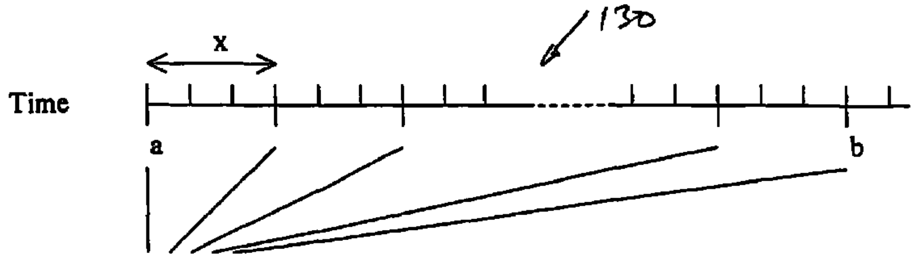
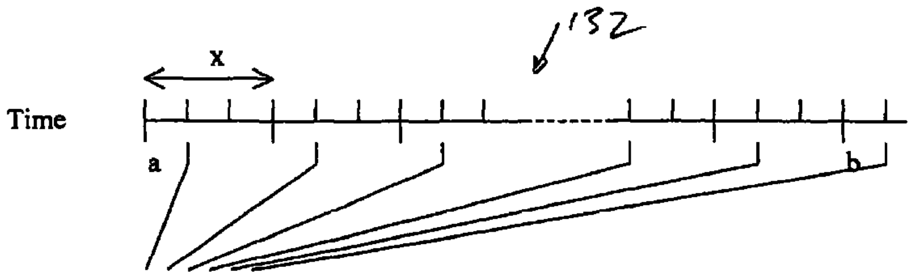

(MESSAGE REACHES DOC)
98
IDENTIFY MESSAGE TYPE AS INTERVAL DATA MESSAGE AND IDENTIFY METER MODULE ID
100
FIND IN DATABASE THE INTERVAL CONSUMPTION TABLES REPRESENTED BY T_{P1}, T_{P2} AND T_{P3}, AS STORED FOR THE METER MODULE IDENTIFIED
102
DECODE INTERVAL CONSUMPTION VALUES FOR P1, P2, P3 USING THE TABLES POINTED TO BY T_{P1}, T_{P2}, T_{P3}, RESPECTIVELY
104

FIG 8



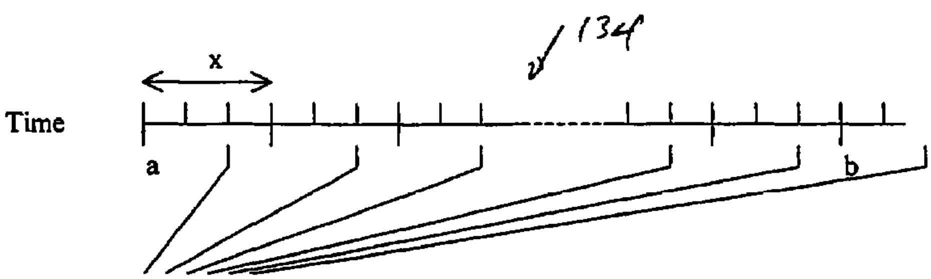
Sample times for Interval Consumption Data Air Message #1

Fig 9A



Sample times for Interval Consumption Data Air Message #2

Fig 9B



Sample times for Interval Consumption Data Air Message #3

Fig 9C

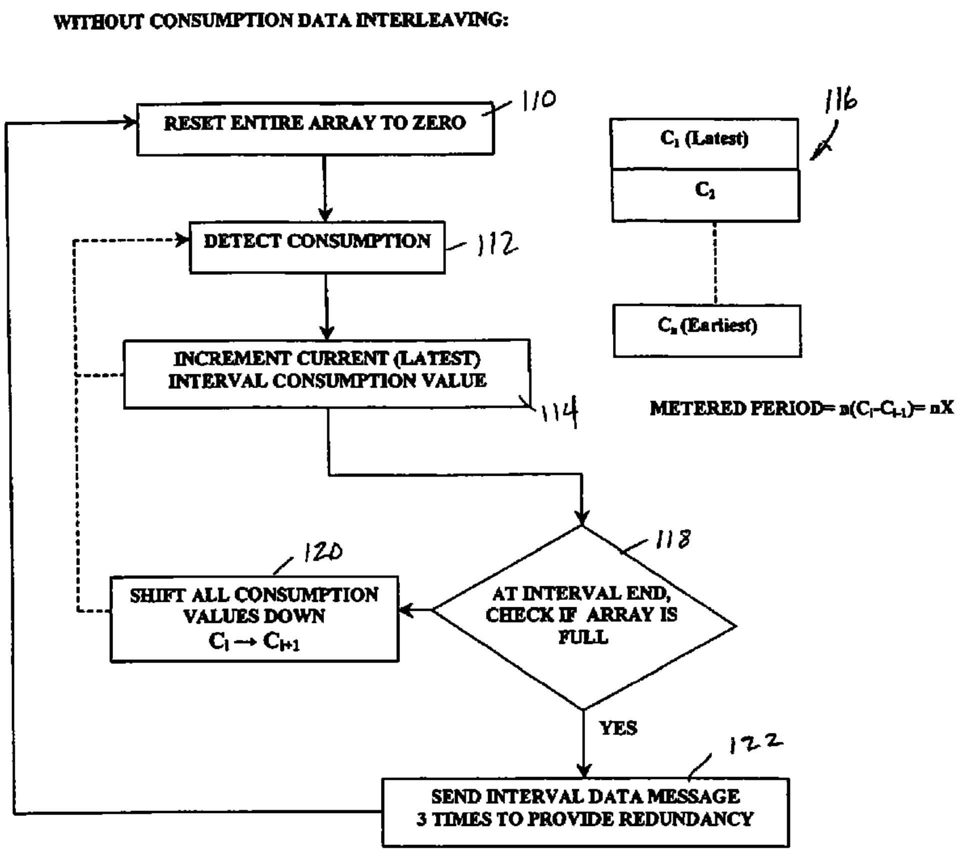

WITHOUT CONSUMPTION DATA INTERLEAVING:
RESET ENTIRE ARRAY TO ZERO
110
DETECT CONSUMPTION
112
INCREMENT CURRENT (LATEST) INTERVAL CONSUMPTION VALUE
114
AT INTERVAL END, CHECK IF ARRAY IS FULL
118
SHIFT ALL CONSUMPTION VALUES DOWN $C_i \rightarrow C_{i+1}$
120
YES
SEND INTERVAL DATA MESSAGE 3 TIMES TO PROVIDE REDUNDANCY
122
116
C_1 (Latest)
C_2
C_n (Earliest)
METERED PERIOD= $n(C_i-C_{i+1})$= nX

FIG 10

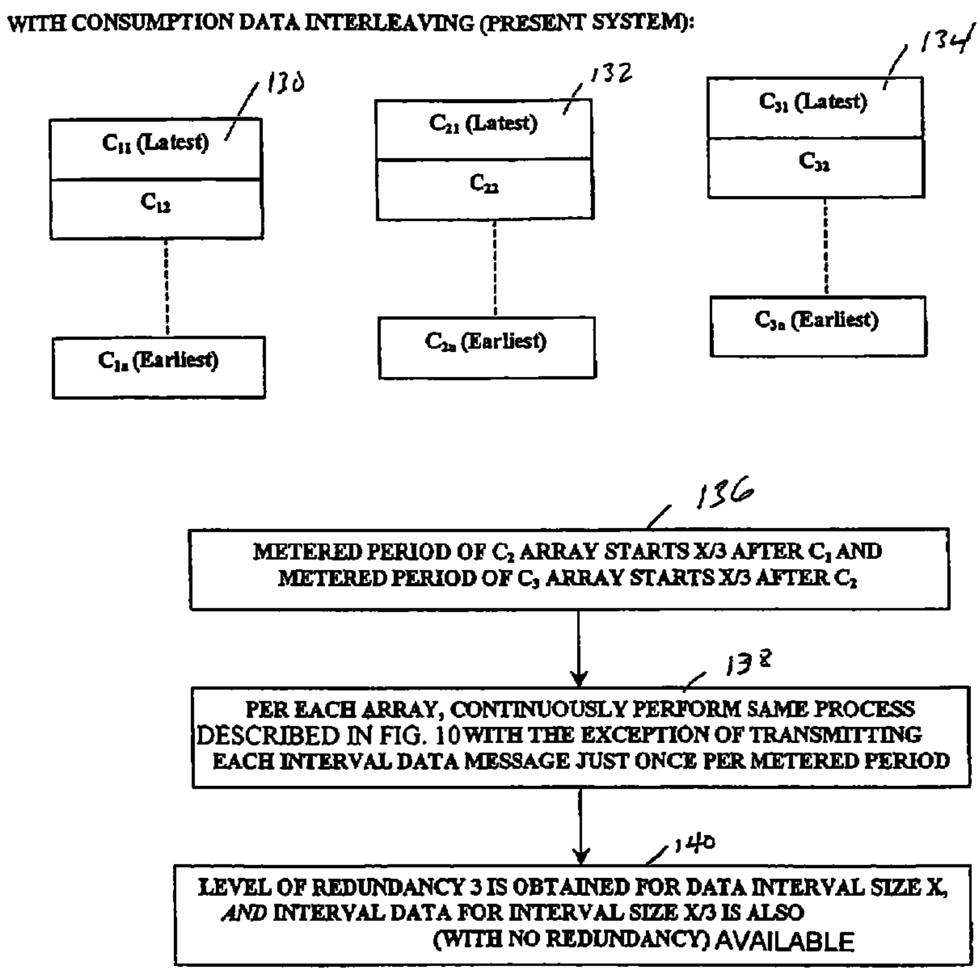

WITH CONSUMPTION DATA INTERLEAVING (PRESENT SYSTEM):
130
C_{11} (Latest)
C_{12}
C_{1n} (Earliest)
132
C_{21} (Latest)
C_{22}
C_{2n} (Earliest)
134
C_{31} (Latest)
C_{32}
C_{3n} (Earliest)
136
METERED PERIOD OF C_2 ARRAY STARTS X/3 AFTER C_1 AND METERED PERIOD OF C_3 ARRAY STARTS X/3 AFTER C_2
138
PER EACH ARRAY, CONTINUOUSLY PERFORM SAME PROCESS DESCRIBED IN FIG. 10 WITH THE EXCEPTION OF TRANSMITTING EACH INTERVAL DATA MESSAGE JUST ONCE PER METERED PERIOD
140
LEVEL OF REDUNDANCY 3 IS OBTAINED FOR DATA INTERVAL SIZE X, AND INTERVAL DATA FOR INTERVAL SIZE X/3 IS ALSO (WITH NO REDUNDANCY) AVAILABLE

FIG 11

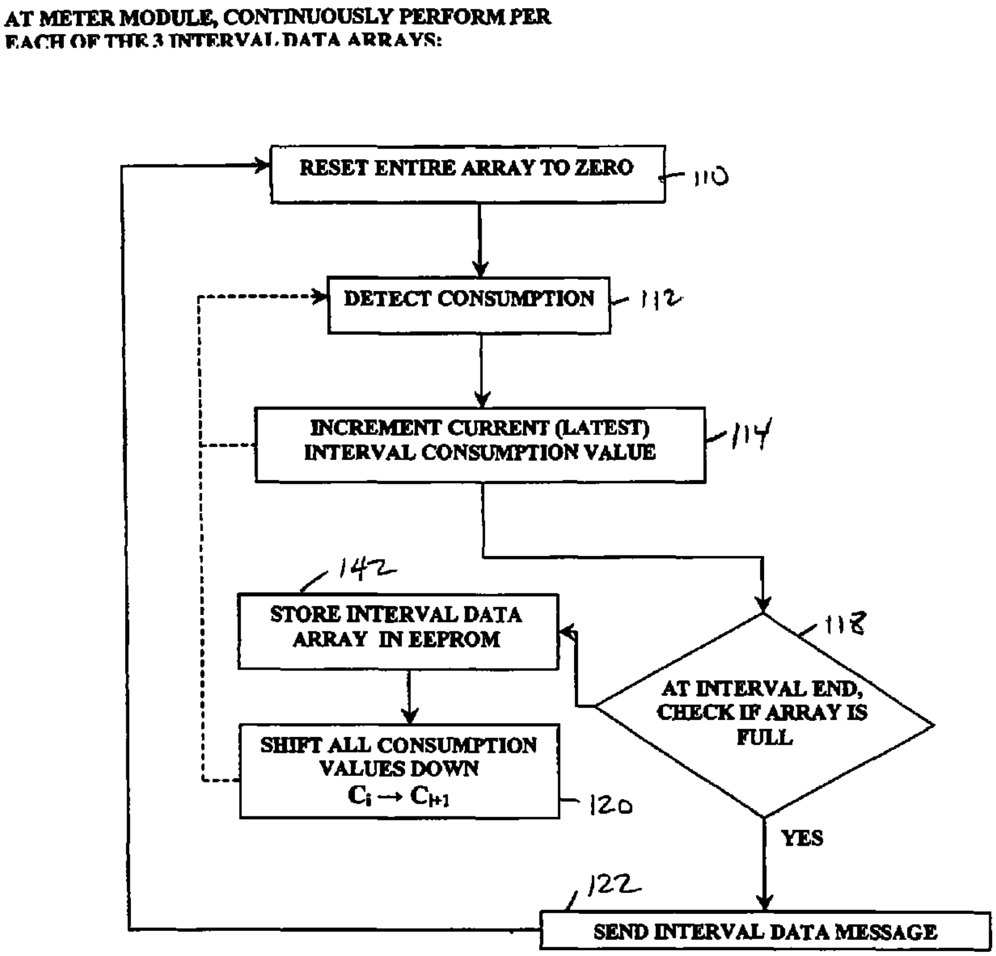

AT METER MODULE, CONTINUOUSLY PERFORM PER EACH OF THE 3 INTERVAL DATA ARRAYS:
RESET ENTIRE ARRAY TO ZERO
110
DETECT CONSUMPTION
112
INCREMENT CURRENT (LATEST) INTERVAL CONSUMPTION VALUE
114
142
STORE INTERVAL DATA ARRAY IN EEPROM
118
AT INTERVAL END, CHECK IF ARRAY IS FULL
SHIFT ALL CONSUMPTION VALUES DOWN
$C_i \rightarrow C_{i+1}$
120
YES
122
SEND INTERVAL DATA MESSAGE

Fig 12

WHEN OUTAGE IS DETECTED BY METER MODULE:

144 TRANSMIT 'LAST GASP' OUTAGE TYPE MESSAGE

↓

148 WHEN POWER IS RESTORED, TRANSMIT 'POWER RESTORED' TYPE MESSAGE, FOLLOWED BY 3 INTERVAL DATA MESSAGES USING INTERVAL DATA ARRAYS LAST SAVED IN EEPROM

FIG 13

INTERVAL DATA RECONSTRUCTION AT DOC:

146 DOC IS INFORMED BY WAY OF 'LAST GASP' OUTAGE MESSAGE OR OTHER AUTOMATED INPUT, OF OUTAGE TIME AT A METER MODULE

↓

148 POWER IS RESTORED AND DOC RECEIVES FULL DATA MESSAGE WITH METER READING

↓

150 DOC RECEIVES 3 INTERVAL DATA MESSAGES C_{11}-C_{1n}, C_{21}-C_{2n}, C_3-C_{3n}

↓

152 DOC RECONSTRUCTS INTERVAL DATA PRIOR TO OUTAGE ACCORDING TO INTERVAL DATA ARRAYS RECEIVED AND THE TIME AND METER READING OF THE OUTAGE

FIG 14

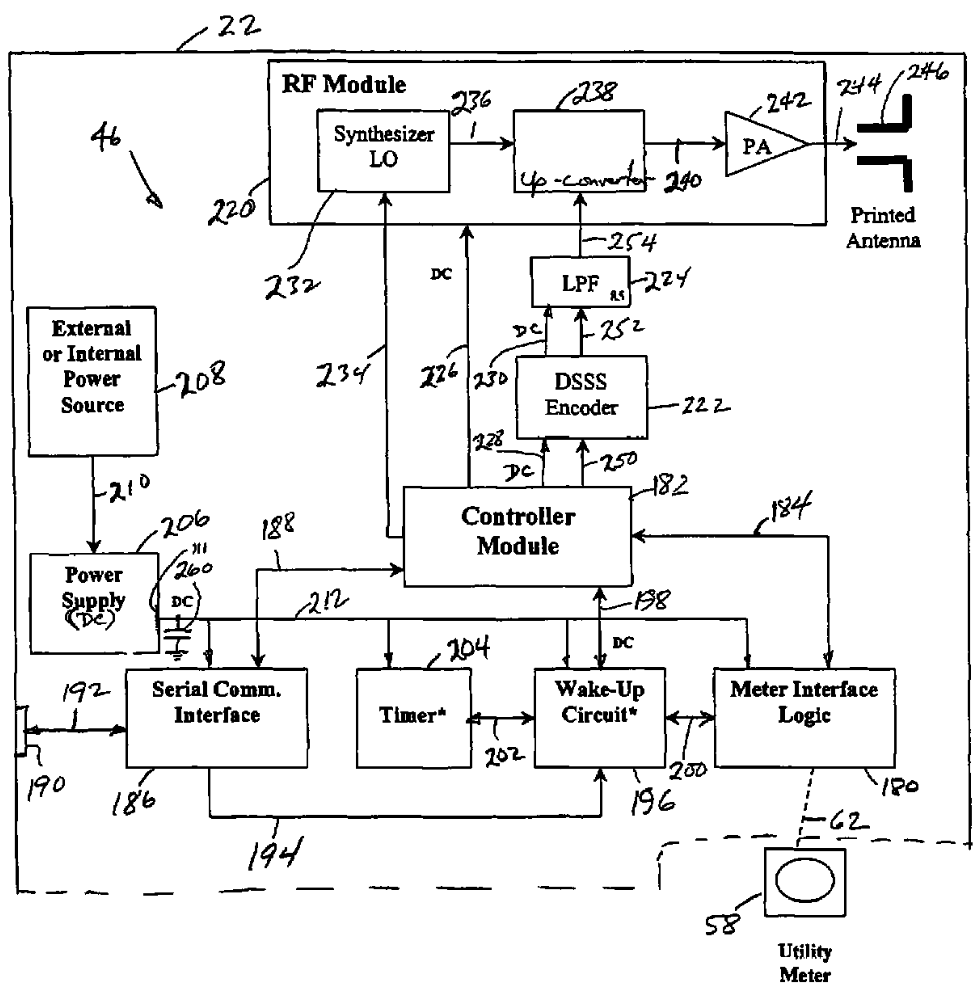

22
46
RF Module
Synthesizer
LO
Up-converter
PA
Printed
Antenna
LPF
DSSS
Encoder
External
or Internal
Power
Source
Controller
Module
Power
Supply
(DC)
DC
Serial Comm.
Interface
Timer*
Wake-Up
Circuit*
Meter Interface
Logic
Utility
Meter

FIG 15

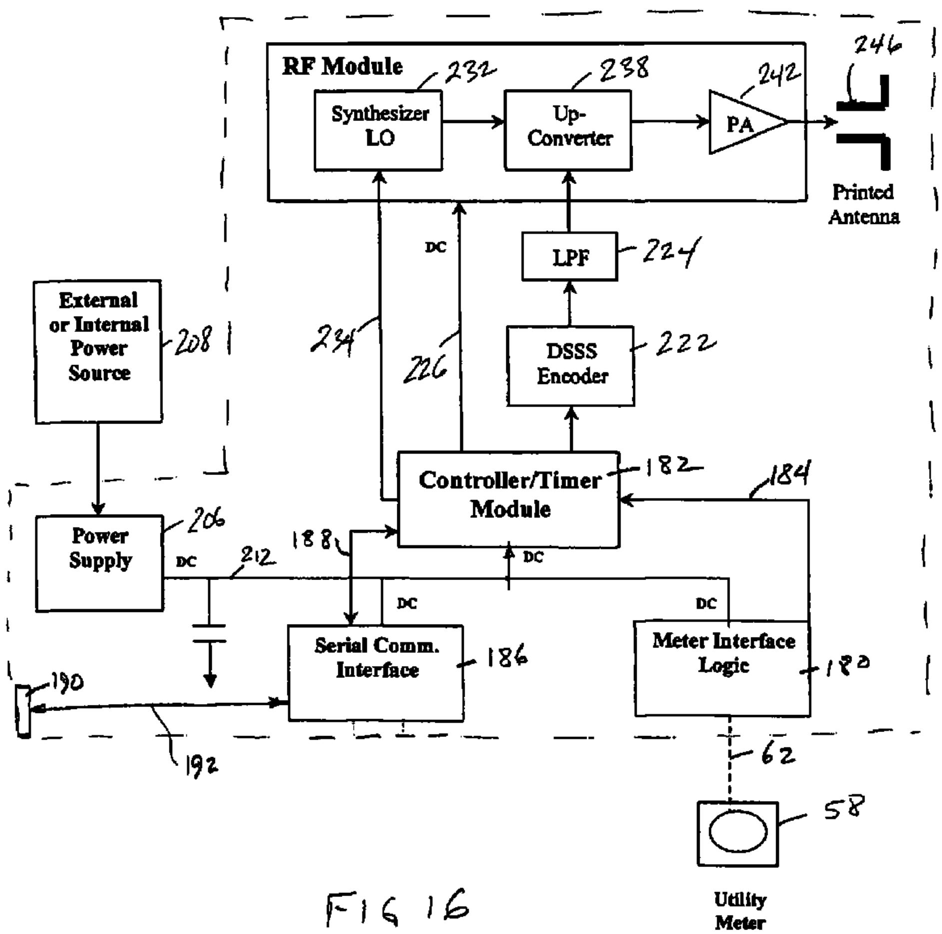

RF Module
232
238
242
246
Synthesizer LO
Up-Converter
PA
Printed Antenna
DC
LPF
224
External or Internal Power Source
208
234
226
DSSS Encoder
222
Controller/Timer Module
182
184
Power Supply
206
DC
212
188
DC
DC
DC
Serial Comm. Interface
186
Meter Interface Logic
180
190
192
62
58
Utility Meter

FIG 16

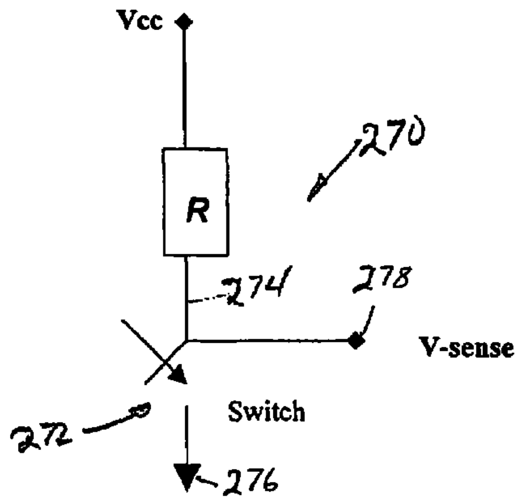


FIG 17
(PRIOR ART)

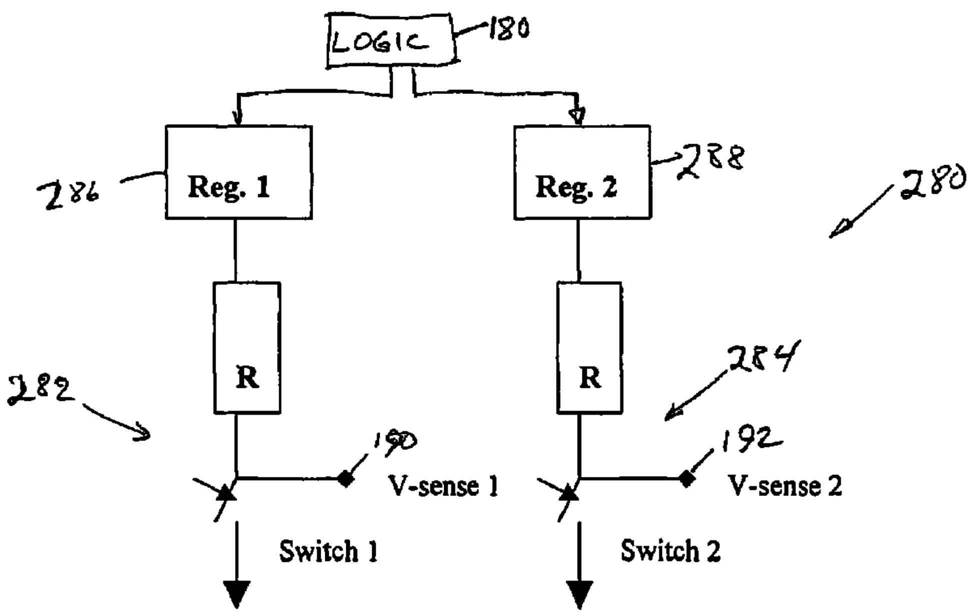


FIG 18

MODULAR WIRELESS FIXED NETWORK FOR WIDE-AREA METERING DATA COLLECTION AND METER MODULE APPARATUS

CROSS REFERENCE TO RELATED APPLICATION

This application is a continuation of U.S. application Ser. No. 10/199,108, filed Jul. 22, 2002 now U.S. Pat. No. 7,012, 546, which is a continuation-in-part of U.S. application Ser. No. 9/950,623, filed Sep. 13, 2001 now U.S. Pat. No. 7,009, 530.

The present invention generally relates to wireless messaging systems and methods. In particular, the present invention relates to wireless messaging systems and methods for automated meter reading (AMR) and metering data collection.

BACKGROUND

Automated Meter Reading (AMR) was developed as a more efficient and accurate method for utility meter data collection, as compared to prior manual meter reading of electric, gas and water meters, and several important advantages of AMR over manual meter reading helped develop it into a specialized branch of the data communications and telemetry industry. Worth noting among these advantages are the reliability, accuracy and regular availability of such metering data, which may be collected from hard-to-reach meter locations as well as from standard meter locations; higher customer security (no need to enter homes) and satisfaction (accurate bills); and reduced cost of customer service call center and service house calls for settling billing disputes.

Various technologies have been used in previous AMR systems to perform the tasks of interfacing the meter in order to sense consumption, communicating consumption data to a central site, and storing consumption data in a computer system at the central site. Wireless technologies, which have become the most common in AMR system implementation due to the ease of the installation process and, in many cases, the low initial and operating costs of the system, include both mobile data collection systems and fixed-base data collection systems, or networks. Although both provide a more reliable method of collecting monthly meter reads for billing purposes, fixed networks have some distinct, and important, advantages, brought about by the capability of such systems to provide frequent (typically at least daily) consumption data collection, which is difficult to do with typical mobile systems. Other advantages include: flexibility of billing date; marketing tools such as time-of-use (TOU) rates, demand analysis and load profiling, which enable clearer market segmentation and more accurate forecasts for utility resource generation, and also serve the goal of energy conservation and efficient consumption; and maintenance tools such as immediate notification of utility resource leakage or of account delinquency. These advantages have triggered increased interest and commercial activity regarding fixed network data collection systems for utilities, particularly utilities in regions undergoing deregulation of utility services.

Several methods and systems for implementing fixed-base data collection from a plurality of remote devices, such as utility meters, to a central location, have been developed and introduced in the past years. A categorization has evolved within the AMR industry, generally differentiating between one-way and two-way wireless data networks. Some systems require that each meter module on the network be a two-way module, i.e. contain a receiver circuit in the meter module. Although two-way communication features such as on-demand meter reading and other remote commands for meter configuration and control are generally desirable, they may not be required for the entire meter population of a utility. Since the inclusion of a receiver in the meter module contributes significant cost to the module, it would be most desirable to allow a utility service company the flexibility to deploy an AMR network which may contain and support both one-way and two-way meter modules.

One-way (collection only) data networks can support the large volume of data expected with the use of advanced metering applications, as by deploying intermediate data collection nodes, each of which creates a small data collection cell with a short-range RF link and a typical service population of several hundreds of meters. In such networks, the intermediate data collection nodes receive messages from meter modules, perform metering data analysis, and extract, or generate, specific meter function values to be transmitted to the next level in the network hierarchy. A wide-area network (WAN) may be provided to connect the intermediate level to the higher level. This configuration, which distributes the 'network intelligence' among many data collection nodes, serves the purpose of reducing the data flow into the central database when a large number of meters are analyzed for load profile or interval consumption data. It also serves the purpose of reducing air-message traffic between the intermediate node and the higher-level concentrator node. However, this configuration becomes inefficient in the common case where only a part, or even none, of the meter population requires advanced metering services like time-of-use (TOU) rates, while basic daily metering service is required for the whole meter population. This inefficiency is imposed by the short-range radio link between the meters and the data collection nodes, which significantly limits the number of meters a node can serve, regardless of how many meters need to be read frequently for interval consumption data. In this case, an expensive infrastructure of up to thousands of data collection nodes may be deployed, which often results in a great deal of unused excess capacity. A more efficient network would therefore be desirable, in order to reduce basic equipment cost, as well as to reduce installation and ongoing maintenance costs.

Another inefficiency arises due to the fact that with a large number of data collection nodes, the most cost-efficient wide area network (WAN) layer in these multi-tier networks would be a wireless WAN. However, to avoid interference from meter modules, as well as to avoid over-complication of the data protocols, an additional, licensed frequency channel is typically used for the WAN, adding to the overall cost of services to the network operator. A network composed of only one wireless data collection layer would therefore be desirable, particularly if operating in the unlicensed Industrial, Scientific and Medical (ISM) band.

Yet another disadvantage of networks with distributed intelligence among data collection nodes is the limited storage and processing power of these nodes. A system that could efficiently transfer all the raw data from the meter modules to the network's central database would therefore be desirable, since it would allow for more backup and archiving options and also for more complex function calculations on the raw meter data.

Another prior data collection network includes only a few reception sites, each one capable of handling up to tens of thousands of meters. In order to obtain long communication range, meter module antennas must be installed in a separate (higher and/or out of building) location from the meter module, and wiring must be added between the meter module and the antenna, creating significant additional cost to the meter

module installation, and significantly reducing the commercial feasibility for practical deployment of the network.

None of the above-mentioned systems of the prior art offers a level of flexibility that will enable a network operator to deploy a reliable, low cost, fixed data collection network, which will meet a wide range of AMR application requirements, from basic daily meter reads to full two-way capabilities. Inefficiencies exist in the prior two-way networks, in which the two-way capability is imposed on the entire meter population, and also in the prior one-way networks, in which small cell configuration requires a large, unnecessary investment in infrastructure.

It is therefore desirable to introduce a simple to deploy, but highly scalable, modular, and reliable data collection system, which would offer a wide range of service options, from basic metering, to advanced applications based on interval consumption data, to full two-way applications, while keeping the system's deployment and ongoing costs proportional to the service options and capacity requirements selected for various segments of the meter population.

SUMMARY OF THE INVENTION

According to a preferred embodiment of the present invention, a one-way direct sequence spread spectrum (DSSS) communications network, implementation of which is well-known in the art, is used as the data collection channel (uplink) of an automatic meter reading (AMR) application, and an optional paging network, or other suitable forward (downlink) network, may be used in a cost-effective manner. The invention provides a wide-area data collection network which is capable of supporting as many meters on as large a geographical area as required by the associated metering application.

The communications network may include one-way meter modules (transmitters) each communicatively coupled to a corresponding electric, gas or water utility meter, and may include two-way meter modules (transceivers) each coupled to such a corresponding utility meter. The meter modules are simple to install, and are typically installed inside electric meters, are integrated (as between meter and index) in gas meters, or are provided as external units adjacent to water meters. The meter modules monitor, store, encode and periodically transmit metering data via radio signals (air messages) in an appropriate RF channel, typically within the 902-928 MHz Industrial, Scientific and Medical (ISM) band, allocated by the Federal Communications Commission (FCC) for unlicensed operation.

Metering data air messages are collected by a network of receiver Base Stations (BS), decoded and forwarded to a central location, referred to as a Data Operations Center (DOC), via a communication backbone such as a frame relay network. The DOC communicates with all the base stations, monitors their operation and collects metering data messages from them. The DOC may also be communicatively coupled to a paging network, or other wireless network, for sending downlink commands to the two-way meter modules in the network. By using appropriate design parameters of a DSSS signal transmitted by a meter module, air messages can be received at a range of over 5 miles in urban areas, allowing sparse infrastructure deployment for a wide variety of metering data collection applications.

By applying long range DSSS to AMR applications, a new level of functional flexibility and network efficiency may be obtained. These goals are additionally achieved by a low-cost, energy efficient meter module which provides significant benefits to the system, primarily by contributing to the long range of the wireless link by implementing a direct sequence spread spectrum (DSSS) signal transmitter of high output power and high interference rejection, while consuming very low average power, thus enabling long life (many years) battery operation.

One of the primary advantages of the invention is that it permits use of a long wireless communication link, which provides wide-area coverage with a small number of sites (typically tens of thousands of meters in a five-mile radius per base station), thereby simplifying network deployment, redncing infrastructure initial and ongoing costs, and reducing the number of potential failure points in the network to increase reliability.

Another advantage of the invention is the provision of a modular network architecture, enabling flexibility in network planning in order to optimize cost and capacity in various regions covered by the network. A part of the network's modularity is that a forward (downlink) channel, such as a paging network, can be integrated with the data collection (uplink) channel, providing a convenient transition to supplying data services to both one-way and two-way meter modules.

Still another advantage is the scalability of the network, which enables gradual and cost-efficient increase of infrastructure deployment in order to meet a wide range of application and capacity requirements, including requirements relating to interval consumption data applications. Another advantage is the routing of all raw metering data to the DOC central database, where it can be easily processed, archived and accessed.

Briefly, the invention, in its preferred embodiments, is a scalable and modular fixed-base wireless network system for wide-area metering data collection, composed of at least one of each of a meter module, a receiver base station, and a data operations center. The system in its basic form includes one-way uplink meter modules, but may be scaled up in its air message handling capacity and in its application features by integrating two way meters responsive to a wireless data-forwarding (downlink) channel, thus providing the system operator with considerable flexibility in the choice of network capacity, features and system cost.

The network components of the system of the invention include one-way (transmit only) and two-way (transmit and receive) meter modules, which monitor, store, encode and periodically transmit metering data via radio signals (air messages). Also included are receiver base stations, which receive, decode, store and forward metering data to a central database and metering data gateway, referred to as the Data Operations Center (DOC). Base stations do not perform any meter data processing, but simply transfer decoded air messages to the DOC. The data operations center communicates with all of the network's base stations and receives decoded air messages from the base stations. The DOC processes, validates and stores metering data in a meter database that it maintains for the entire meter population operating in the network and has the capability to export or forward metering data to other systems via standard data protocols.

An optional wireless downlink channel, such as a paging network, may be utilized to provide two-way service to two-way meter modules that may be operating in the network. This downlink channel enables time synchronization and other commands to be sent to two-way meter modules.

The system of the invention permits optimal adjustment of network control parameters such as the quantity of base stations, the number of reception frequency channels, and the meter module message bit rate, according to application requirements such as message delivery probability, metering

data latency and meter module battery life. The system may also include Network Transceiver/Relay (NTR) devices, designed to enhance network coverage in areas of poor or no initial coverage. The NTR devices retransmit messages only from designated meter modules, identified either by module identification number or by an appropriate flag in the meter module air message.

In one embodiment, the system utilizes a logarithmic table encoding method for compressing interval consumption data air messages to reduce the number of bits required in a message for each consumption interval. In this method, the DOC maintains a large list (bank) of consumption encoding/decoding tables, adapted to various consumption patterns. The DOC further maintains a registry specifying which set of encoding/decoding tables is assigned to each meter module with the sets of tables potentially differing from one meter module to another. Also available is an interleaving encoding method for interval consumption data air messages, to increase the redundancy level of the data and/or to provide data for smaller consumption intervals. In this method, the time base for each interval consumption data message is shifted, compared to the previous message, in a cyclic manner, so that interval consumption data may be reconstructed even if some of the messages are not received.

The invention provides a low-cost, high-output-power meter module, which may operate in the system described above. The module includes a sensor, data storage and processing, a direct sequence spread spectrum transmitter which may have an output of between 0.5 and 1.0 waft, and an antenna, all within the same physical enclosure.

The meter module preferably is equipped with a power supply in which a capacitive element and a limited current source are combined, in order to allow high output power during a short transmission burst, which may also be initiated immediately in the event of a power outage. The capacitive element and the limited current source impose a physical limitation on the charge time and thus the transmission duty cycle to reduce interference that can be caused by a malfunctioning meter module to an acceptable level that does not affect network functionality.

The meter module maintains low power consumption in its meter interface circuitry, and low overall power consumption, by using two sensors to detect rotation in the meter being monitored. These two sensors are openable and closeable switches, of which only one (or neither) may have a closed switch status at any given time, with the switches being operated by the operation of the meter, as by rotation of a disk, for example. Each switch is connected to a sensor circuit, and by disabling a sensor circuit as soon as a closed switch state is detected, while simultaneously enabling the other sensor circuit, near zero current is drawn by the sensors.

The meter module also includes an outage recovery system, which provides immediate notification of outage ('last gasp'), immediate notification of power restoration, and storage of interval consumption data prior to an outage event, thereby enabling a transmission of the last saved data shortly after power restoration.

BRIEF DESCRIPTION OF THE DRAWINGS

The foregoing, and additional objects, features and advantages of the present invention will be understood by those of skill in the art from the following detailed description of preferred embodiments thereof, taken with reference to the accompanying drawings, wherein:

FIG. **1** is a block diagram illustrating required and optional components of a data collection network system according to an embodiment of the present invention;

FIG. **2A** is a block diagram illustrating a two-way meter module in accordance with the present invention;

FIG. **2B** is a block diagram illustrating a one-way meter module in accordance with the present invention;

FIGS. **3A** and **3B** are graphic illustrations of consumption data required to be transmitted in an air message;

FIG. **4** illustrates in tabular form examples of encoded logarithmic consumption data;

FIGS. **5A-5D** graphically demonstrate the evaluation process by which a meter module determines which consumption data-encoding table to select;

FIG. **6** is a flowchart of the process of generating logarithmic encoded interval consumption data;

FIG. **7** illustrates the message contents;

FIG. **8** is a flowchart of the process of decoding the transmitted message;

FIGS. **9A**, **9B** and **9C** illustrate interleaving encoding, which is used to generate interval consumption data air messages;

FIG. **10** is a flowchart illustrating the process for generating consumption data messages without consumption data interleaving;

FIG. **11** is a flowchart illustrating the process of generating and handling interleaving encoded interval consumption data messages;

FIGS. **12**, **13** and **14** are flowcharts of consumption data recovery in the event of power outage;

FIG. **15** is a block diagram of a first embodiment of the meter module of the invention;

FIG. **16** is a block diagram of a second embodiment of the meter module of the invention;

FIG. **17** illustrates a prior art 'zero current' rotation sensor;

FIG. **18** illustrates a zero current rotation sensor in accordance with the present invention;

BRIEF DESCRIPTION OF THE PREFERRED EMBODIMENT

Data Collection Network

Turning now to a more detailed description of the invention, FIG. **1** illustrates a scalable and modular wireless fixed-base data collection system, or network **10**, comprising at least one wireless meter module, such as a two-way (transceiver) module **12**, at least one receiver site (base station) **14**, and one central site (data operations center) **16**, into which all metering data is collected. According to a preferred embodiment of the present invention, system **10** is an automatic meter reading (AMR) system which uses a one-way direct sequence spread spectrum (DSSS) communications network as a data collection channel (uplink) **18**. A downlink network **20**, which may be a paging system or other suitable downlink network, provides an optional forward (downlink) channel **21** in a cost-effective manner. The network **10** is designed to provide a cost-effective, wide-area data collection solution which is capable of supporting as many meters in as large a geographical area as may be required by the associated metering application.

The communications system **10** may include one or more one-way meter modules (transmitters) **22** communicatively coupled, for example, to corresponding electric, gas or water utility meters, and may also include one or more two-way meter modules (transceivers), exemplified by module **12**, coupled to such utility meters. The meter modules **12** and **22** monitor, store, encode and periodically transmit metering

data via radio signals (air messages), in an appropriate RF channel, such as the channel 18. This RF channel is typically within the 902-928 MHz Industrial, Scientific and Medical (ISM) band, allocated by the Federal Communications Commission (FCC) for unlicensed operation. Metering data messages are collected by a network of receiver base stations 14.

By using appropriate design parameters for a DSSS signal transmitted by meter modules 12 and 22, air messages can be received at the remote base stations 14. In a preferred embodiment, a signal of 1 Watt of output power, a raw data bit rate of 4000 bits per second, a high antenna efficiency (near 1) and a processing gain of 24 dB are used. In addition, appropriate error correction methods, as known in the art, are incorporated; for example, a convolution code with R value of ½ and K value of 5, combined with a data interleaving mechanism may be used. The reception range can then be estimated by using empiric models such as the Okumura model, which represents path losses in an urban environment, yielding an expected reception range of over 5 miles in urban areas, allowing sparse infrastructure deployment for a wide variety of metering data collection applications. The Data Operations Center (DOC) 16 communicates with all the Base Stations (BS), monitors their operation and collects metering data messages from them. The DOC 16 may be communicatively coupled to two-way modules in the network 10 by way of downlink network 20, which preferably is a paging network, a cellular network, or other wireless network, for sending downlink commands to the two-way meter modules using suitable, wireless data protocols.

Since transceiver power consumption is greater than transmitter power consumption, it is generally preferable to use transmitters where the power source is limited. Gas and water meter modules generally have a limited power source, typically from a battery, so the meter modules attached to such meters are generally transmitters rather than transceivers. Electric meters can typically take their power from the electric grid, so their power is not limited, and hence transceivers are suitable for electric meters. However, because the cost of the transceiver meter module is greater than the cost of the transmitter meter module, electric meters may use a transmitter to save on the end unit cost. Thus, it is preferred that gas and water meters use transmitters only, while electric meters may use transmitters or transceivers according to the application requirements. The transceivers create a two-way system, which has the advantage of greater capacity than a one-way system, and which can provide additional services (such as remote connect or disconnect, over-the-air programming or reprogramming of meter module parameters, and others) that cannot be provided by a one-way system. The metering data collection system operates as a one-way data collection system if not coupled to a downlink channel. The basic one-way network may be scaled up to several higher levels of capacity and application features, as described herein, the highest level being reached by integrating a downlink channel in the system.

The system 10 thus comprises both one-way (transmitter) meter modules 22 and two-way (transceiver) meter modules 12 coupled to corresponding meters. All of the modules are able to transmit encoded DSSS radio signals representing metering data stored in the meter modules, such as current meter reading, tamper status, meter identification data and interval consumption data. A variety of utility meter module types (electric, gas, water) and models may operate in one metering data collection network, utilizing the module, base station and data operations center infrastructure. Each receiver base station 14 is able to receive and decode DSSS encoded signals (air messages) generated by any of the meter modules 12 or 22. The bandwidth of the DSSS signal is approximately 2 MHz, and the base stations are preferably optimized to receive signals in any radio frequency range between 800 MHz and 1 Ghz. In a preferred embodiment, the data collection network operates in the ISM band under the rules for unlicensed operation (Part 15 of the FCC Rules), and requires no licensing for any portion of its wireless uplink channel 18.

According to the preferred embodiment, one or more base stations 14 are deployed to cover a geographic area. The number of base stations needed depends on the size and type of terrain within the geographic coverage area, as well as upon application requirements. A base station is typically installed at a high location (communication tower or roof top) and consists of at least one receiving antenna, RF cables and connectors, a DSSS receiver, and a communication interface such as a PPP router or CDPD modem. A base station may also contain a backup power source for continued operation during a specified period of outage. Base stations 14 receive metering data air messages from meter modules 12 and 22 on the uplink channel 18, decode the radio signals, and relay the decoded metering data air messages to the DOC 16. The DOC preferably is coupled to the base stations 14 via standard communication channels 24, which typically may be using an IP network (such as frame relay or Internet). Other communication channels may be used between the DOC and the base stations, and such channels may be a wireless cellular network, CDPD, PSTN or a satellite data network.

The DOC 16 preferably includes, or has access to, a database 25 of all the meter modules 12 and 22 in the network 10, and an Internet server enabling remote access to the database. This embodiment also may include email, fax, pager devices or voice message generators in the DOC 16 to provide alerts and event notification to the network users. The DOC 16 may be programmed to forward received data directly to a user or to export files to a buffer directory by using standard data protocols.

According to the preferred embodiment, the DOC 16 includes suitable programs for metering data validation, processing and storage, while the role of the base stations 14 is to decode air messages and forward raw metering data to the DOC for central processing. This network structure eliminates the need to monitor and control metering data processing tasks, which are carried out in multiple locations; instead, all metering data is stored in a central location, enabling fast data access response times. Further, the central location (DOC) is equipped with suitable backup storage means to provide a permanent record of all received data. Thus, two objectives are served: low initial and maintenance cost of base station hardware and software; and convenient, permanent access to all metering data collected by the network via one central data repository.

The basic architecture of the network includes transmitter meter modules 22, base stations 14 and a DOC 16. However, the network is modular and may include a downlink network 20 and two-way meter modules 12, as well as message relaying devices 30 in the uplink (reverse) RF channel 18. In addition, as will be further described, the network 10 includes a variety of scalability mechanisms enabling cost-effective service in varying levels of network air-message traffic and various metering data applications.

According to a particular embodiment of the invention, a cost-efficient means for expanding network coverage is the addition of a Network Transceiver/Relay device (NTR) 30, for example in one or more of the channels 18 to provide coverage for meter modules experiencing poor or no base station coverage. This provides more flexibility to the net-

work operator by creating another option for providing coverage to a limited geographic area. The cost of deployment and maintenance of an NTR is significantly lower than that of a base station so that, besides being a cost effective solution to poor coverage, it also may justify the enhancement of a network's coverage to areas of low population density, thus extending the reach of the automated metering data collection system. The deployment of NTR devices does not require the network operator to perform any changes in any of the other elements of the network infrastructure.

In the design of the system **10**, an analysis of expected radio traffic may indicate sufficiently high radio traffic to cost-justify full base station coverage. However, in any network it is likely that there will be certain areas, or "holes", in which radio traffic will be very sparse and which cannot cost-justify Base Station coverage. NTRs may then be used to provide sufficient coverage at much lower cost. For example, a small number of meters might be located in a deep valley, and so might not be covered by the nearest base station, but the deployment of a new base station might not be economically justified. In this case, an NTR, which only needs to provide limited coverage and thus is smaller in size than a base station, may be mounted at a common site such as on a pole top, so that its ongoing site lease cost would be significantly lower than that which an additional base station would require. The use of a NTR is thus a low-cost means of covering holes in the coverage of the base station network, or of extending the network's coverage to areas of low air-message traffic.

The network transceiver/relay device **30** illustrated in FIG. **1** may receive metering data messages from one or more meter modules **12** and **22**, and operates to decode and retransmit messages from specific meter modules. NTR devices **30** are used in specific terrains that endure poor radio coverage, as described above, or may be used to remedy other situations where there is a lack of coverage or where coverage degradation occurs. The NTR **30** preferably is a low cost data relay node, which includes a DSSS receiver that may have lower RF sensitivity and smaller coverage (hundreds of meters) than a base station, and that also includes a DSSS transmitter. Like the base station, the NTR does not perform any metering data analysis; it only receives, encodes and retransmits raw data air messages that are identified as coming from specified meter modules listed in the NTR's memory. The relayed messages may then be received by a nearby base station **14**.

In another embodiment, the NTR **30** may include a program which checks for an NTR flag bit in a received air message that indicates whether or not to relay the message. If desired, this embodiment may be combined with the above-described embodiment in which the NTR **30** only receives air messages from listed meter modules to allow selection of specific meter modules which will have their air messages retransmitted, with each meter module being programmed to use its NTR flag in order to have only some of its air messages retransmitted. This enhances network coverage, without creating unnecessary air message traffic.

One embodiment of a two-way meter module, such as that indicated at **12** in FIG. **1**, is illustrated in the block diagram of FIG. **2**A. This module is capable of transmitting metering data air messages on demand; for example, upon receiving an appropriate downlink wireless command. Alternatively, or in addition, the module may also be conveniently programmed to transmit at specific times by incorporating and maintaining a real-time clock which may be synchronized, for example, by a suitable signal transmitted in the wireless downlink channel **21**. Two-way meter modules preferably also receive, decode and execute other commands such as commands to program meter parameters, to display messages or alerts on the meter's display, and to disconnect and reconnect power to the utility meter's load.

As illustrated in FIG. **2**A, the two-way module **12** incorporates a receiver **40** connected by way of inlet line **42** to an antenna **44**, and a transmitter **46** connected by way of outlet line **48** to an antenna **50**. The receiver **40** may be a pager receiver, for example, and includes an output line **52** connected to a POCSAG/Flex Decoder **54** which receives and decodes downlink wireless command signals for controlling the module. One decoder output line **56** leads to a meter **58**, which may be a utility meter or the like as discussed above, to provide command signals to the meter, while a second decoder output line **60** leads to the transmitter **46** to control its operation; for example, to turn it on and off at selected times. The meter **58** is connected to the transmitter **46** by way of meter output line **62**, to supply data which is to be transmitted.

FIG. **2**B is a block diagram of a one-way meter module **22**, which includes a transmitter such as the transmitter **46** of the module **12**, connected to antenna **50** by way of line **48** and to meter **58** by way of line **62**. The transmitter in this module is controlled by an internal clock to operate periodically to transmit data from the meter **58**. The basic transmitter apparatus will be described below. A trade-off exists between the amount of data required by a particular use of the system and the maximum number of air message transmissions that can be accommodated while still maintaining air message traffic or meter module battery life at acceptable levels. In the preferred embodiment, the system is designed so that the network operator or deployment planner has the flexibility to optimize space diversity, frequency diversity and air message duration according to the various requirements of delivered metering data, meter module battery life, metering data latency, and air message delivery probability.

To meet these various requirements, five different levels of network capacity control may be provided by the system, depending upon customer demand, it being noted that levels 2 to 5 described below may be implemented in any order. The most basic system capacity may be defined as Level 1, wherein a sparse base station network is deployed, combined, if necessary, with NTR devices which would cover areas with very limited radio traffic. This level, which provides adequate geographic coverage and a minimum level of system capacity, is roughly defined as the network capacity required in order to provide daily readings of meters in an urban meter population. A typical urban deployment for this level would include base stations spaced 5 miles apart, each covering up to several tens of thousands of meters, with few to no deployments of NTR devices. As an example, a basic configuration may utilize one RF channel, and provide daily coverage for 99% of an area, in which 50,000 meters are deployed and are transmitting daily, the area being covered by five Base Stations. Additional capacity requirements may be triggered by significant growth in the meter module installed base and/or by new applications requiring more data to be delivered daily from each meter module. In order to maintain a desired level of data collection services, one of the four measures described below may be used.

To obtain a higher, Level 2, system capacity, a space diversity technique is used. In this arrangement, the number of base stations is selected to provide coverage for a specified meter population and a specified metering data application in a specified geographical area. In the initial phase of planning, the system coverage for this level includes selection of the optimal number and locations of base stations to be deployed in the specified area. However, when a base station covers a large area and the meter module density or air message fre-

quency requirements increase above the initial design coverage, at some stage the farthest meter modules encounter interference from the closer meter modules, and message reception probability from the farthest meter modules decreases. To overcome this problem, base stations may be added at appropriate locations in the same geographic area, thereby increasing network capacity and message reception rate. Adding base stations reduces the effective range between each deployed meter module and the base station closest to it, so that more meter modules, or potential meter module locations, are within a range of high air-message reception probability. Thus, the placement of additional base stations in the same geographic area, without any other change in the network or the meter modules, will in itself increase overall network capacity.

Another approach to increasing network capacity, defined as Level 3, utilizes frequency diversity, which is implemented by utilizing more than one frequency for uplink channels within a given coverage area. The uplink channels **18** would normally operate on the same radio frequency, but selected meter modules may be programmed to alter their transmission frequency channel; for example, to transmit each successive air message on a different frequency. To accommodate this, the corresponding base station would include several receivers each tuned to a different frequency, or a single receiver having multiple frequency channels, thus significantly increasing the base station's air message reception capacity. Frequency diversity may eliminate or at least postpone coverage problems, which would otherwise require adding base station sites. In addition, frequency diversity may be combined with space diversity by feeding receivers operating in different uplink frequency channels at the same base stations with signals from separate antennas. In the 902-928 MHz unlicensed ISM band, a particular embodiment of the network may operate in up to 57 channels, spaced 400 kHz apart, but a more practical limit for reliable operation would be about 10 channels. Each new frequency channel added to a receiver increases the base station's capacity, and when a regional base station network is being used, adding channels significantly increases the entire network's capacity.

Still another approach to increasing system capacity, defined as Level 4 and which may be included in the preferred embodiment of the system, consists of modifying the length of the direct sequence code used to encode the command and data signals in the network, although this forms a trade-off with the air message's raw data bit rate parameter. In one embodiment of the invention, for example, the direct sequence chip rate for the code may be 1 Mchips/sec with a maximum code length of 255 chips, yielding a data rate of about 4 kbps. To modify this, the network operator/planner may select shorter codes, namely 63, 31 or 15 chips long, thus increasing the raw data bit rate. Reducing code length reduces the signal spreading and decreases the coverage range per base station, but on the other hand increases each base station's air message capacity because of the shortened air messages.

The highest level of air-message capacity, which may be defined as Level 5, can be attained in a data collection network by utilizing a downlink channel and two-way transceivers rather than one-way transmitter meter modules. A two-way system has the inherent potential to be more efficient with radio air time resources, since field units may be synchronized to a central clock to allow transmission only in allocated time slots. The higher the number of two-way meter modules in a metered population, the higher is the network capacity increase provided by adding the downlink channel. A wireless data collection network in which the modules incorporate transceivers as described above may be scaled up from one-way (data collection only) to two-way, simply by connecting the DOC **16** to a wireless downlink channel **20**. The measures described in levels 2 to 4 above may be implemented in such a two-way network as well, in order to further increase network capacity.

Integrating a downlink channel such as channel **20** is a cost-efficient scaling-up procedure, which provides significant enhancement of both network air-message capacity and metering data application functionality. This enhancement does not require the network operator to perform any changes in any of the already existing elements of the network infrastructure, if the modules already contain transceivers.

In a preferred embodiment of a two-way metering data system **10**, both one-way (transmitter) and two-way (transceiver) meter modules are utilized. Transceivers can be interrogated for data at the time that the data is required, thus eliminating the need for the retransmitted transmissions which are required in a one-way network in order to maintain a certain level of data latency. In addition, by synchronizing all transceiver modules to one central real-time clock, a time slot for transmission may be allocated and specified for each transceiver in a coverage area, thereby increasing the efficiency of network air time usage. Although several advanced metering applications, such as demand and Time of Use (TOU) metering, are available from a one-way metering data collection network, two-way meter modules operating in the described two-way metering data network are capable of providing additional features, such as accurate interval consumption data measurement enabled by a regularly synchronized real-time clock, on-demand meter reading, remote disconnect and reconnect, remote programming of meter parameters, and remote notification of rate changes or other messages. The particular embodiment of the data system of the present invention enables the operator to mix on the same network, in a cost efficient manner, low cost transmitters, which provide a wide range of metering data collection features, and higher cost transceivers, which further enhance metering data application features, while maintaining the core advantages of sparse infrastructure and the low cost associated with unlicensed operation of the metering data collection branch of the network.

In addition to the scalability and flexibility provided by the levels of network architecture described above, another key feature of the system is application scalability, which is a cost-efficient method of enhancing the metering applications supported on the network. As described above, some application features, including on-demand meter reading, remote disconnect and reconnect, remote programming of meter parameters and remote notification of rate changes or other messages, require that the network architecture be scaled up to a two-way network by adding a downlink channel. However, some applications based on interval consumption data, such as demand analysis, load profiling, and time of use rates, can operate successfully on a one-way network and, by using the method described hereinbelow, only a relatively minor increase in air message traffic occurs.

Consumption Data Encoding Methods

In the prior art, extensive infrastructure is deployed in order to collect interval consumption data frequently (e.g. every 15 minutes). However, in many cases, particularly in residential metering applications, consumption data may be required in high resolution, but some latency is permitted in data availability. For example, fifteen-minute demand analysis could be required, but may be performed each morning on data collected the previous night, allowing several hours in which to collect the required interval consumption data. It would,

therefore, be beneficial for the network service provider to have the flexibility to deploy infrastructure appropriate to the application and invest in additional infrastructure for high-end applications, such as on-demand reads, only in proportion to the meter population for which it is required.

Such interval consumption data measurements may be obtained from a meter, in accordance with one embodiment of the invention. Such a measurement normally includes an array of interval consumption values, each one of the values representing the consumption increment of one interval. The meter module transmits a regular ('full data') message, that contains the exact absolute reading of the meter several times a day, and in addition transmits several messages daily ('interval data messages') that include the interval consumption data array and a reference reading (e.g. the least significant two digits of the meter reading). As a one-way system, the data collection network does not rely on a real time clock in the meter module, but rather uses a time stamp generated by the DOC. Therefore, the following method is used for generating interval consumption data at the DOC: when an interval data message is received, the DOC traces the most recently received full data message and 'completes' the most significant bits of the meter reading at the time of the interval data message. Then, using the increment values received in the interval data message, an absolute meter reading can be generated for all the intervals included in the interval data message. The result is an increasing function representing the meter reading at each interval, which is stored at the DOC.

In order to reduce the total length of air messages, or the total number of fixed-length interval data air messages transmitted by a meter module, a method referred to as "logarithmic table encoding" of consumption values is used, which encodes interval consumption data in the air message. This method maps the range of consumption values into a more limited number of values, for the purpose of reducing the number of bits of information transmitted over the air, with the mapping being executed by a series of tables, which are predefined according to the expected dynamic range of interval consumption values.

The charts **70** and **72** illustrated in FIGS. **3**A and **3**B are respective examples of aggregate and interval consumption versus time data that may be required by a demand analysis application. In this example, it is assumed that an accuracy of 0.1 kWh is sufficient. Also by way of example, consumption is measured over a 12 hour total time period during 15 minute intervals. In order to optimize a consumption profile, this total time period may be divided into several sub-periods; in this example, 3 periods of 4 hours each. A table showing numeric measured values for each interval is illustrated in FIG. **3**B. In prior meter reading systems, these values would be encoded for transmittal, and this would traditionally require an encoding table with values ranging from zero to 1800 Wh, in 100 Wh increments, i.e. 19 values, requiring 5 bits per each consumption interval to encode.

In the present invention, the overall air message traffic associated with interval consumption data applications is reduced by using, in this example, only 2 bits for interval consumption encoding. This encoding requires some approximation, which inevitably creates an error in the reconstruction of a consumption profile compared to the actual consumption, but by appropriate definition of a set of encoding tables for the meter module to use, an acceptable error level may be reached. Flexibility in assigning different encoding tables for different sub-periods also reduces the statistical errors in the decoded consumption profile.

The set of tables assigned to a meter module may differ from one meter module to another, according to the expected consumption patterns. The DOC maintains a bank of available tables from which a set of tables is defined for each meter module during installation. An example of such a set of encoding tables is shown in FIG. **4**.

The meter module selects an encoding table from its assigned set of tables by building a consumption profile with each of the tables stored in its memory, and comparing it to the actual profile (FIG. **3**A), stored in its memory as the aggregate of a series of actual interval reading values (FIG. **3**B). Then the meter module applies a criterion by which to select the best encoding table; e.g. the table that yields the lowest maximum error during the metered period, or the lowest variance between the encoded and actual profiles.

The encoded consumption profile is built in the following process: if during an interval, actual (aggregated) consumption reaches a value X, the interval consumption value which would bring the encoded consumption profile to the closest value less than or equal to X, and which is also represented by a two-bit code in the encoding table, is used in order to build the encoded consumption profile. Examples of constructed profiles vs actual consumption for Tables 1-4 of FIG. **4** are shown in FIGS. **5**A-**5**D, respectively. In the examples, if a minimum error criterion is applied for the 6-10 four-hour period shown, then Table 3 would be chosen for transmission, as it yields a maximum error of 200 Wh (0.2 kWh) during the period. A table is selected for transmission for the other two periods in the example of FIG. **3**B (**10-14**, **14-18**) in an identical process. A reverse process is applied at the DOC in order to extract the interval consumption data. Thus, the table set used by the meter module is retrieved and then the consumption profile is reconstructed for each sub-period.

A summary of the logarithmic encoding and decoding process is shown in FIG. **6**, where, for each sub-period **P1**, **P2**, **P3**, interval consumption values are calculated using each of the available four tables **T1**,**T2**,**T3**,**T4** as illustrated at blocks **80**, **82** and **84**. After each calculation, a criterion is applied for each period to select the most suitable table for encoding the interval consumption of that period, as illustrated at blocks **86**, **87**, **88**, **89**; and **90**, **91**. Two bits that identify the table that was used for each period are also attached to the air message (total of 6 bits in the example), and the message is transmitted, at block **92**. The transmitted message is illustrated in FIG. **7** as including a message header **94** which includes the identification (ID) of the meter module which has calculated the data, and then includes the data itself, as indicated at **96**.

As illustrated in block **98** of FIG. **8**, when the DOC receives the message from a meter module, it identifies the type of message and the ID of the transmitting module, as indicated at block **100**. The DOC then determines the tables to which the table identifiers in the message refer (block **102**), and once the tables are identified, the DOC decodes the interval data encoded in the message into actual consumption (Wh) values (block **104**).

As illustrated in FIG. **7**, an interval consumption air message in the provided example may contain 2-bit interval data for **48** intervals of 15 minutes; i.e. 96 bits, plus two bits identifying the table chosen for each of the three sub-periods, plus 10 bits as a reference meter read, plus a message header of 40 bits, for a total of 152 bits, compared to 5 bits×48 intervals, which would amount to 240 bits and a total of 290 bits including the header, in a traditional system with no logarithmic encloding. Thus, airtime usage or the number of required messages is reduced by about 47% using the described method.

In order to provide a high level of redundancy of interval consumption data, another data encoding method is provided, referred to as interval consumption data "interleaving air

message encoding", which splits interval consumption values between separate messages. In a particular embodiment, depicted graphically in FIGS. **9**A-**9**C, and in FIG. **11**, three separate interval consumption data air messages **130**, **132** and **134**, are transmitted that relate to the same consumption period b-a. The first air message includes samples taken at times a, a+x, a+2x, . . . and is transmitted at time b. The second air message includes samples taken at times a+x/3, a+4x/3, a+7x/3, . . . b+x/3, and is transmitted at time b+x/3. The third air message includes samples taken at times a+2x/3, a+5x/3, a+8x/3, b+2x/3, and is transmitted at time b+2x/3, as illustrated at block **136** in FIG. **11**. More generally, in order to spread transmissions during the day, the offset between interval data arrays may be x/3+Nx, where N is an integer.

In a prior art interval consumption data handling method, described in FIG. **10**, an interval consumption data array **116** is generated by filling the value C_1 with the incremental consumption of the current interval (block **114**), and shifting down all of the array cell values at the end of each interval X (block **120**). That way, after a metered period of nX, n values relating to the last n intervals are stored in the AMR module. Once the array is full it is ready for transmission (block **118** to block **122**). If, for example, a redundancy level of 3 is desired, it is obtained by sending each interval data message three times (block **122**). Then the array is set to zero (block **110**) and starts aggregating data for the next interval data message.

In a particular embodiment, described in FIG. **11**, the present system provides a redundancy level of 3, by storing three interval consumption arrays (**130**, **132** and **134**), while having their time base cyclically shifted by X/3 from each other (block **136**). Per each array, the meter module executes the same process described in FIG. **10** (block **138**), with the exception of needing to transmit the interval data message just once. The redundancy is provided by having three interval data arrays covering the same metered period, although not having the same interval start and end times within that metered period.

With interleaving encoding, internal consumption data is defined to have a resolution value corresponding to the size of the time interval between consecutive consumption values sampled. If a message is lost, interval consumption data is still available at the DOC with a resolution of x or better. If no messages are lost, the DOC can reconstruct the absolute reading in x/3 intervals. i.e. with a resolution of x/3, illustrated at block **140**. This way, the meter module maintains the potential to provide high resolution interval consumption data, but also provides lower resolution interval consumption data with a higher redundancy level than that available when data is not split as described above, as illustrated at blocks **138** and **140**.

Although each of the methods may be applied independently, by combining the two encoding methods described, a highly reliable and efficient interval consumption data collection system is provided. In the example of FIGS. **3**A and **3**B, 8 daily messages, which include two regular metering messages (not containing interval data) and six interval data messages (each one 152 bits long, as in the example above) are required to deliver interval data, with a redundancy level of 3, whereas without using the provided methods, and using a comparable message size of 150 bits, two regular metering messages and twelve interval data messages, or a total of 14 daily messages, would be required to achieve the same redundancy level. Therefore, the encoding methods provided by the present invention maintain high channel reliability while increasing network capacity, by 75% in this example.

The system of the present invention supports interval consumption data applications even when a power outage occurs. This is performed by appropriate utilization of the meter module non-volatile memory, and without requiring any backup battery. A method, combined with the methods described above for data encoding, for retrieving interval consumption data in a one-way data collection network after an outage event has occurred utilizes a meter module which periodically and frequently executes a procedure to update and store interval consumption data messages,—as illustrated in FIG. **12**. The purpose of this process is to prevent loss of interval consumption data upon the occurrence of an outage event. The flowchart of the data recovery process related to an outage shown in FIG. **12** is similar to that of FIG. **9**, but further includes storing consumption data in an EEPROM **142**. If an outage occurs, the meter module uses its power supply (referred to below in the meter module description) to generate a 'last gasp' message (block **144**, FIG. **13**) that indicates to the DOC (block **146** in FIG. **14**) that power is out for this meter module. Upon power restoration after outage (block **148**), the meter module's microcontroller "wakes up", and transmits a full data message which includes usual identification information, the reading from the EEPROM and also includes a flag signifying that power has just been restored as illustrated at block **146**. At the same time, a new interval consumption data cycle (period) begins, and shortly thereafter the last saved three interval data message (arrays C_{11}-C_{1n}, C_{21}-C_{2n}, C_{31}-C_{3n}) are sent.

As illustrated in FIG. **14**, block **150**, after the DOC identifies the power restoration message flag, it receives the interval consumption messages that follow it as the last saved interval consumption messages, enabling the DOC to reconstruct interval consumption data (block **152**) prior to the outage event. In addition, the next scheduled full data message, which follows the power restoration message is also flagged by the meter module as the 'second full data message since power restored'. This acts as a redundant measure to identify the last saved interval consumption message before the outage event. In order to provide interval data recovery after outage even in case the 'last gasp' message was not received, the time of outage can also be input to the DOC from other systems (such as a utility customer information system).

Meter Module

The meter module apparatus used in the present system has unique features of low overall power consumption, high output power and low cost overall design, enabling long battery life and long communication range in a commercially feasible fixed wireless network for a variety of metering applications. Each meter module in the network continuously monitors the resource consumption according to an input sensor that is coupled to the utility meter. In a particular embodiment, the meter module may be integrated inside, or as a part of, the meter enclosure, but in any case the meter module stores and transmits a wide array of data fields related to the meter, including consumption data, meter identification and calculation factor data, and various status alerts. The meter readings are stored as an aggregated value and not as incremental values, thus maintaining the integrity of the meter reading if an air message is not received at the DOC.

A one-way meter module **22** (FIG. **2**B) transmits a metering data air message once every preprogrammed time interval, and a block diagram of a first embodiment of the module is depicted in FIG. **15**. In this particular implementation, the module includes a meter interface logic module **180** that collects consumption, tamper status and other data from an associated utility meter **58**. It should be noted that although FIG. **15** depicts a single meter interface module **180** for purposes of simplification, multiple meter interface logic modules may be used in a single transmitter to interface with

corresponding utility meters. The meter interface logic module 180 operates continuously and draws only a small amount of current. It includes several standard sensors (not shown), such as magnetic reed switches or optical sensors to track consumption, tilt sensors for tamper detection, and voltage sensors to determine outage or power restoration events.

The module 22 also includes a controller module 182, whicb typically is a microprocessor, connected to the interface logic module 180 by way of connector 184 and connected to a serial data communication interface 186 by way of conductor 188. The interface 186 includes a short-range wireless magnetic loop output or other conventional personal computer data port (not shown) connectable by way of input port 190 and conductor 192 for testing and initialization of the transmitter at the shop or in the field. The interface 186 is also connected by way of conductor 194 to a wake-up circuit 196 which, in turn, is connected by way of connector 198 to the controller 182, by way of conductor 200 to the meter interface logic module 180, and by way of conductor 202 to a timer circuit 204.

A DC power supply 206 is connected to an internal (battery) or external power source 208 by way of conductor 210, with the DC power supply 211 output being connected by way of conductor 212 to corresponding inputs for interface 186, timer 204, wake-up circuit 196, and meter interface 180. The wake-up circuit 196, when activated, connects the DC power on line 112 to conductor 198, to thereby supply power to controller module 182.

In the illustrated embodiment, the controller module 182 uses the auxiliary wake-up circuit 196 to manage a minimal power consumption level during the times in which the meter module is inactive ("sleep mode"). Upon receipt of a command from the controller 182, the wake-up circuit 196 operates an electronic switch to disconnect the power supply from the controller itself, thereby also disconnecting the RF transmitter module to be described, thus allowing very low overall power consumption of the meter module during a "sleep" period. The wake-up circuit connects power back to the controller when triggered by an output from the meter 58 by way of interface 180, by an external device by way of the port 190 and interface 186, or by the timer 204. This capability of the meter module is a particular value in battery-operated transmitters. However, it will be understood that if there is an unlimited power source, as may be the case if utility meter 58 is an electric meter, the controller 182 may operate continuously, in which case the wake-up circuit 196 would not be needed, as illustrated in FIG. 16. In this second embodiment of an electric meter module illustrated in FIG. 16, the timer 204 is a part of the controller module 182, and the DC power conductor 212 is connected directly to the controller module 182, instead of being connected through the wake-up circuit.

The meter module 22 also includes a radio frequency (RF) module 220, a DSSS encoder 222, and a low pass filter (LPF) 224, connected to the power supply output conductor 212 by way of the controller module 182 and respective conductors 226, 228 and 230. The RF module 220 includes a synthesizer-controlled local oscillator (LO) 232 which is controlled by the controller module 182 by way of conductor 234 to provide a carrier output signal on line 236 to an up-converter 238. The carrier signal is modulated in converter 238, and the modulated output is supplied by way of output conductor 240 to a power amplifier (PA) 242, the output of which is fed by way of output conductor 244 to an antenna 246.

When the controller 182 determines that an air message is to be transmitted, it prepares a data packet, as described above, which is sent to encoder 222 by way of conductor 250, where it is converted to a direct sequence through PN code generation and signal spreading. The spread signal is supplied by way of line 252 to the low pass filter (LPF) 224 where it is filtered and sent by way of line 254 to up-converter 238 where it is used as the modulating base-band signal for the signal to be transmitted. The power amplifier 242 produces up to 1 W of power for output to antenna 246, which preferably is an on-board printed antenna. In the embodiment which utilizes the wake-up circuit 196, once the controller 182 has handled the event that woke it up from its power-down mode, whether an air message transmission or other task was performed, it returns to its power-down (idle) mode.

In a preferred embodiment of the meter module of the invention, the power supply 206 is limited in order to maintain an acceptable level of radio interference in the event of uncontrolled transmission by a malfunctioning meter module, for one source of danger in the system is the possibility that a transmitter will malfunction and begin transmitting continuously. The result may be that the entire frequency channel would be blocked in that coverage area during the time of transmission, until the transmitter's power source dies. If the power source is a battery, this would be a relatively short period, but the interference would continue indefinitely if the power source is unlimited, such as would be the case if the meter is connected to an electric grid. Although this event is highly unlikely, in the meter module 22 described herein, a cost effective mechanism has been introduced to prevent uncontrolled transmission. This mechanism provides two additional benefits to the system: high output power with a limited power source and an immediate outage notification feature, also known as a 'last gasp' transmission.

The meter module's power supply 206 includes two specific physical limits to prevent continuous uncontrolled transmission; namely, a capacitive element 260 connected between output conductor 212 and ground, and a limited current source. The capacitive element 260, which is used as a buffer stage between the energy source 206 and the load connected to output line 212, stores sufficient energy to provide a high-power air message transmission, but due to its inherent physical limitations, the capacitive element can deliver sufficient power for transmission for only a limited period of time. Since the duration of transmission is relative to the capacitance of element 260, and capacitance is related to the size of the element, the size of the capacitive element 260 is selected to be big enough to deliver enough energy for a complete transmission session, but not more than that. This way, the maximum potential blockage duration due to unwanted transmission is restricted to one transmission session. In addition, the limited current source in power supply 206 imposes a physical limitation on the recharge time required for the capacitive element to reach the required energy level for another air message transmission, thus limiting the on-off transmission duty cycle to a level that is harmless in terms of network capacity.

In a particular embodiment of the invention, the transmitted power is one watt, for a duration of 150 msec, and the power supply provides a recharge time of 90 seconds. This translates into a maximum of 960 messages per day, or 144 seconds a day, which is about 0.16% of the available time. Since network coverage is designed with a much higher safety margin, a malfunctioning transmitter would not be destructive to the network operation, allowing sufficient time for detection and identification of the source of the problem.

The described power supply enables the transmitter to generate high-power air message transmissions, even with a power source having a very low current drain. It also enhances electric metering applications by enabling a 'last gasp' meter-

ing data air message transmission when an outage event is detected by an electric meter module, if the capacitive element is fully charged.

As an illustrative example of the design and power supply we assume the following:

1. The transmission duration is 150 mSec.

2. The out put power is 1 Watt.

3. The power amplifier efficiency is 40% and its operation voltage is 5 Volts.

4. Minimum time between transmissions—90 seconds.

The energy required for a single transmission is 1 Watt×0.15 Sec/0.4=0.375 J. The energy stored in a capacitor is equal to $E=0.5\times C\times(Vi^2-Vf^2)$ when C is the capacitor capacitance, Vi is the initial voltage of the capacitor and Vf is the voltage which remains in the capacitor after the completion of the transmission. Since the power amplifier requires 5V regulated voltage, a reasonable voltage for Vf is 8V. Selecting the capacitor's capacitance C and Vi can be done in more than one way, so additional considerations can be made, such as the availability of the selected capacitor in the market, its price, its size etc. If, for example, the capacitance is selected to be 2200 uF, then in this case Vi is equal to 20V. Since the device that converts the energy stored in the capacitor to a constant regulated 5V voltage to feed the power amplifier (typically a step down regulator) has less than 100% efficiency (typically 90%), Vi may be adjusted, taking into account the efficiency of the regulating device. A simplified charger can be implemented as a simple current source. Since the minimum time between transmissions is 90 seconds, the current source should be able to charge the capacitor from 8V to 20V in 90 seconds. Since $I=C\times dV/dT$, we get $I=2200$ uF×12/90=0.3 mA.

Conventionally, a utility meter such as meter **58** includes a rotating sensor which responds to the utility being monitored; for example, an electrical meter typically incorporates a rotating disk which responds to utility usage to drive the meter indicators. The rotation of such a disk can be monitored by a suitable sensor such as a magnet or a light sensor, for remote detection. Preferably, appropriate sensor circuitry and logic for this purpose is used in the meter interface logic **180** to enable the meter to be read with nearly zero power consumption, particularly in cases where the meter module **22** is powered by a limited power source, such as a battery.

A typical prior art sensor configuration is illustrated at **270** in FIG. **17**, and includes a switch **272** which is located in a meter **58** and has two operation states, open (illustrated) and closed. The switch is positioned to be activated periodically by a pin, or register, mounted on a rotating disk in the meter, in known manner. When the switch is open the circuit from voltage source Vcc through conductor **274** to ground point **276** is broken and the voltage measured at the V-sense node **278** equals the supply voltage Vcc. When the switch **272** is closed, the voltage measured at the V-sense node is the circuit's ground level reference voltage; i.e. zero voltage. Measuring the two electrical states at the V-sense node **278** allows the two switch states open and closed to be distinguished, with the periodic opening and closing in response to rotation of the disk providing a measure of utility usage.

Although most switches have finite conductivity, it is very low, and the typical power consumption when switch **272** is in the open state is acceptable for long operating life. However, during the closed state, power is consumed at a level that may be significant when the energy source is limited, as with battery-powered devices, and when that limited source must remain operative for lengthy periods of time, as is often the case with meter modules. In addition, the amount of energy wasted in this way typically cannot be predicted, and may vary widely with utility customer consumption patterns.

A preferred alternative to the sensor configuration of FIG. **17** may be referred to as a "Zero Current Sensor Configuration", and is illustrated at **280** in FIG. **18**. This implementation is based upon a component selection and geometrical arrangement of two sensor switches located in meter **58**, in which only one of the two switches may be triggered to a closed switch state for any possible position of a sensed rotating element.

In meter configuration **280**, two switches **282** and **284** are connected in series with respective registers **286** and **288**. These registers are activated or deactivated by control commands from the controller module **182** (FIG. **15**) by way of logic interface **180** and connector **62**. Loading a high state voltage from interface **180** into a meter register causes activation of the associated switch **282** or **284**, respectively. Loading a low state voltage into a meter register causes deactivation of the associated switch **282** or **284**. When a switch is deactivated by its register, no current can flow through the switch, even when the switch is closed. When no current flows, no energy is wasted, and this occurs when the switch is open, or when the switch is de-activated by its register, without regard to whether it is open or closed.

The controller module **182** is programmed to deactivate one of the two sensors through logic **180** by deactivating a sensor register as soon as a closed switch state is detected in that sensor. In addition, the controller module immediately activates the other sensor through its register. For example, if switch **282** is open and register **286** initially has a high voltage state, then switch **282** is activated, but open. When this switch detects a predetermined condition, such as a projection element (magnet/reflector/pin) on a meter rotor, it changes its state from open to closed, and the voltage at node **190** (V-sense **1**) is changed from the high state voltage of register **286** to zero. This voltage drop is detected by interface **180** which wakes up the controller module **182**. The controller then deactivates switch **282** by loading a low state voltage in register **286**, and at the same time it loads a high state voltage in register **288** to activate the open switch **284**. This latter switch is located in a different projection zone than switch **282**, and since switch **284** is open, no current flows. Since switch **282** is now deactivated, no current flows through that switch either.

When the rotation of the meter disk or wheel continues and the projection element reaches the projection zone of switch **284**, it changes its state from open to closed, the voltage at node **292** (V-sense **2**) is changed from high state voltage to zero, and the controller unit **182** is awakened and immediately deactivates switch **284** and activates switch **282**. One rotation of the disk or wheel is defined as a state change of switch **282** from open to closed, followed by a state change of switch **284** from open to closed, after which the controller **182** increments the meter revolution count. Since neither switch is ever active and closed in this configuration, the continuous current drain of the sensor circuitry only includes that of the open switch, which is near zero.

Although the invention has been described in terms of preferred embodiments, it will be understood that numerous modifications and variations may be made without departing from the true spirit and scope thereof, as set forth in the following claims:

What is claimed is:

1. A fixed-base wireless network system for wide-area metering data collection, comprising:

a plurality of meter modules, each meter module to monitor, store, encode, selectively insert a receive/transmit flag bit in the transmitted metering data and periodically transmit metering data;

at least one receiver base station to receive, decode, store, and forward metering data;

at least one network transceiver/relay device
to receive and decode messages including the metering data from said plurality of meter modules,
to identify, from the decoded messages, messages received from specified meter modules among said plurality of meter modules according to a list of the specified meter modules stored in a memory of said at least one network transceiver/relay device, the list of the specified meter modules specifying a subset of the plurality of meter modules,
to encode and retransmit a first decoded message identified as being received from a meter module included in the list of the specified meter modules upon determination that the first decoded message includes the receive/transmit flag bit inserted by the meter module included in the list of the specified meter modules, and
to not retransmit a second decoded message identified as being received from the meter module included in the list of the specified meter modules upon determination that the second decoded message does not include the receive/transmit flag bit; and
a data operations center to communicate with said receiver base station, receive decoded metering data from said receiver base station, and validate and store metering data in a database for said plurality of meter modules.

2. The network system of claim **1**, wherein said data operations center is connected to export or forward metering data.

3. The network system of claim **1**, wherein at least one of said plurality of meter modules includes a direct sequence spread spectrum radio frequency transmitter for transmitting metering data messages via radio signals at a radio frequency.

4. The network system of claim **3**, wherein said radio frequency is between 800 MHz and 1000 MHz.

5. The network system of claim **1**, wherein at least one of said plurality of meter modules is a one-way transmitter meter module.

6. The network system of claim **1**, wherein at least one of said plurality of meter modules is a two-way transceiver meter module.

7. The network system of claim **6**, further comprising:
a wireless downlink network to transmit commands including at least one of time synchronization, programming, display, disconnect, and reconnect commands to said at least one two-way transceiver meter module.

8. The network system of claim **1**, wherein said plurality of meter modules includes at least one one-way transmitter meter module and at least one two-way transceiver meter module.

9. The network system of claim **1**, wherein said metering data includes interval consumption data.

10. The network system of claim **1**, further comprising:
a plurality of receiver base stations, a number of the plurality of receiver base stations and the positions of the plurality of receiver base stations being selected based on at least one of message delivery probability, metering data latency, and meter module battery life for a given meter module message bit rate.

11. The network system of claim **1**, wherein said plurality of meter modules each include a sensor, a data storage device, a processing device, a direct sequence spread spectrum transmitter, and an antenna, all within the same physical enclosure.

12. The network system of claim **11**, wherein said enclosure is assembled inside an electric meter enclosure.

13. The network system of claim **11**, wherein said enclosure is assembled between a gas meter and a gas meter index.

14. The network system of claim **11**, wherein said transmitter has an output power between 0.5 and 1 Watt.

15. The network system of claim **1**, wherein at least one of said plurality of meter modules includes a limited current source power supply and a capacitive element charged by the limited current source, the limited current source power supply limiting a charge time of the capacitive element to limit a transmission duty cycle of said at least one meter module to reduce interference that may be caused by malfunction.

16. The network system of claim **11**, wherein said sensor comprises two sensor elements to detect rotation, the two sensor elements fixed at respective positions so that, at any given time, no more than one of the two sensor elements is at a closed switch status.

17. The network system of claim **16**, wherein at least one of said plurality of meter modules further comprises:
switch circuitry to disable a first of the two sensor elements and enable a second of the two sensor elements, in response to a closed switch status of the first of the two sensors, and to disable the second of the two sensor elements and enable the first of the two sensor elements, in response to a closed switch status of the second of the two sensors.

18. The network system of claim **11**, wherein the processor is configured
to direct the transmitter to transmit a power outage message indicating that power is out, when a power outage occurs,
to direct the transmitter to transmit an identification message including a data flag indicating that power has just been restored, when power is restored after a power outage occurs, and
to direct the transmitter to transmit a message including last-saved data intervals, when power is restored after a power outage occurs and after the identification message is transmitted.

19. The network system of claim **1**, wherein said at least one network transceiver/relay device is further configured
to retransmit a first encoded identified message of the encoded identified messages automatically, based on a receive/transmit flag bit of a decoded message corresponding to the first encoded identified message that indicates retransmission, and
to retransmit a second encoded identified message of the encoded identified messages, when a retransmission command is received by said at least one network transceiver/relay device, based on a receive/transmit flag bit of a decoded message corresponding to the second encoded identified message that indicates retransmission based on a retransmission command.

20. The network system of claim **1**, wherein at least one of said plurality of meter modules transmits successive messages on respective radio frequency channels, and said at least one receiver base station includes a receiver having multiple frequency channels.

21. The network system of claim **6**, wherein said at least one meter module is time synchronized to a central clock based on transmit commands transmitted over said wireless downlink network and transmits messages during allocated time slots based on transmit commands transmitted over said wireless downlink network.

22. The network system of claim **1**, wherein
at least one of said plurality of meter modules includes a direct sequence spread spectrum radio frequency transmitter to transmit metering data messages, and
a Post Office Code Standardization Advisory Group (POCSAG) or FLEX receiver to receive and decode commands.

23. A fixed-base wireless network system for wide-area metering data collection, comprising:

a plurality of meter modules to monitor, store, encode, periodically transmit metering data, and selectively insert a receive/transmit flag bit in the transmitted metering data;

at least one receiver base station to receive, decode, store, and forward metering data;

at least one network transceiver/relay device

to receive and decode messages including the metering data from said plurality of meter modules,

to encode and retransmit a first decoded message received from a meter module upon determination that the first decoded message includes the receive/transmit flag bit inserted by the meter module, and

to not retransmit a second decoded message received from the meter module upon determination that the second decoded message does not include the receive/transmit flag bit; and

a data operations center to communicate with said receiver base station, receive decoded metering data from said receiver base station, and validate and store metering data in a database for said plurality of meter modules.

24. The network system according to claim 1, wherein each meter module is further configured to

select an encoding table from a plurality of encoding tables that minimizes an error associated with encoding the meter data, and

encode the meter data according to the selected encoding table.

25. The network system according to claim 23, wherein each meter module is further configured to

select an encoding table from a plurality of encoding tables that minimizes an error associated with encoding the meter data, and

encode the meter data according to the selected encoding table.

* * * * *

CC1

US. Patent 9,494,480 Claim Chart - Broniak 9,019,120

'792 Claim 1 CC1	
A water use and monitoring and leak detection apparatus comprising:	Abstract - Methods and systems are disclosed for monitoring water leaks within a home. A home network with various devices monitors these devices with a controller.
a base station designed to be connected to a main water supply means;	Col. 3, line 36-40 - A main water meter 52 is operatively connected to the main water inlet pipe 50 for measuring a total amount of water flow into the home and communicating information gathered to the controller 10 via a communication module 56.
said base station includes a joint means for connecting to a cold/ambient water supply, or a joint means for connecting to a cold/ambient water supply and a joint means for connecting to a hot water supply, said base station have a joint means for connecting to outgoing water supply line(s) for a home residence, company or building structure;	Col. 3, line 36-40 - A main water meter 52 is operatively connected to the main water inlet pipe 50 for measuring a total amount of water flow into the home
electrical circuitry including one or more microprocessors or microcontrollers with a power source contained with said base station apparatus;	Col. 2, lines 60-67 - The controller 10 includes a microprocessor, which is programmed to selectively send and/or receive signals to a device control board 24 and 26 of devices 12 and 14, for example, in response to the input signal it receives.
said power source is either AC powered, DC powered, or powered with one or more batteries, said power source is electrically connected to said electrical circuitry;	
one or more flow sensors in communication with a water supply, said one or more flow sensors in electrical communication with said electrical circuitry;	Col.3, lines 52-55 - … includes at least one water meter or flow meter for measuring water that is consumed by a water consuming device and communicating information gathered to the controller 10 via a communication module 56.

one or more wired or wireless electrical communication means, said or wired wireless electrical communication means having the capability to transfer water parameter, water energy and/or water quality information or data to one or more remote apparatuses, said wired or wireless electrical communication means utilizes protection technology to securely provide water use, water energy and/or water quality information and/or data in a confidential format;	Col. 4, lines 57-65 - The controller 10 connects via either Ethernet or Wi-Fi to the homeowner's router and to a client application 34, for example, in a personal computer 36 and/or a mobile device 38. The controller 10 also has the ability to periodically transmit data to a central server on the Internet 40. This allows for remote service and monitoring capability. A server 42 can keep records of all homes therein that may be accessed remotely via the Internet.
said base station includes mesh-enabled circuitry that can communicate with other base stations for transferring water flow, water energy and/or water quality data;	
said base station(s) functioning as one or more access points that transfer said water flow, water energy and/or water quality data, using encryption and identification technology to an internet connection;	
said water flow, water energy and/or water quality data transferred over the internet connection to one or more remote computers or computer servers, and;	
said remote computers or servers allow registered owners and users to access their registered water flow, water energy and/or water quality data using a cell phone, smart phone, ~~or~~ mobile phone, or a mobile electronic communication device.	
'792 Claim 2 CC1	
a base station in close proximity to a main water supply;	Abstract - Methods and systems are disclosed for monitoring water leaks within a home. A home network with various devices monitors these devices with a controller.
said base station includes a joint means for connecting to a cold/ambient water supply, or a joint means for connecting to a cold/ambient water supply and a joint means for connecting to a hot water supply, said base station have a joint means for connecting to outgoing water supply line(s) for a home residence, company or building structure;	Col. 3, line 36-40 - A main water meter 52 is operatively connected to the main water inlet pipe 50 for measuring a total amount of water flow into the home and communicating information gathered to the controller 10 via a communication module 56. Col. 3, line 36-40 - A main water meter 52 is operatively connected to the main water inlet pipe 50 for measuring a total amount of water flow into the home
said base station further comprising a first power supply, said first power supply is either AC powered, DC powered, or powered with one or more batteries, said first power supply electrically	Col. 2, lines 60-67 - The controller 10 includes a microprocessor, which is programmed to selectively send and/or receive signals to a device control board 24 and 26 of devices 12 and 14, for

connected to a first circuitry which has one or more microprocessors or microcontrollers;	example, in response to the input signal it receives.
one or more water flow sensors in communication with a water supply, said one or more water flow sensors in electrical connection with a first electrical circuity;	Col.3, lines 52-55 - … includes at least one water meter or flow meter for measuring water that is consumed by a water consuming device and communicating information gathered to the controller 10 via a communication module 56
said base station monitors and processes water parameter data including water flow, water energy, and/or water quality data;	
said base station includes software that controls and sequences the water parameter data and prepares said data for wired or wireless transfer;	
a receiving station, said receiving station having a second electrical circuitry including one or more second microprocessors, said receiving station remotely located from said base station;	
said receiving station having a second power supply, said second power supply is either AC power, DC power, or powered with one or more batteries, said second power supply electrically connected to a second circuitry;	
said first electrical circuitry of said base station is in wire or wireless communication with said second electrical circuity of said receiving station;	
said receiving station designed to establish Wi-Fi, Bluetooth or ZigBee electrical communication with a wireless router/server, and/or cellular communication with a cell tower technology, and any combinations thereof;	
said receiving station includes mesh-enabled circuitry that can communicate with other receiving stations for transferring water flow, water energy and/or water quality data to one or more access points;	

said receiving station or a custom transfer apparatus functioning as one or more access points for transferring said water flow, water energy and/or water quality data over an internet connection to one or more remote computers or computer servers; and	
said computer servers allow registered owners and users to access their registered water flow, water energy and/or water quality data using a cell phone, smart phone, mobile phone or a mobile electronic communication device.	
5. The water use monitoring and leak detection apparatus of claim 1, further comprising said base station including an electronic water control valve wherein said base station is programmed to automatically turns off the main water supply when a leak is detected or alternately can send an alert signal when a leak is detected to ~~a~~ said cell phone, smart phone, mobile phone, or other mobile electronic communication device wherein a user is provided an election to send a command to the base station to control the electronic water control valve to turn off or leave on the main water supply.	Abstract - A shut off valve can be triggered remotely when a request is received from the user, which closes the water pipeline to prevent water damage. Col. 5, lines 10-24 - … the system 8 includes shut off valves 58, 68, and 78 at respective pipelines 50, 60 and 70. The central controller 10 may receive input from the user or homeowner in response to the warning or message, and the user, for example, may respond with instructions to shut off the pipelines 50, 60, and/or 70 via the respective shut off valve 58, 68 and 78
'792 Claim 7 CC1	
7. The water use monitoring and leak detection apparatus of claim 1, further comprising a water use calibration mode for learning the patterns and signature of water use devices within a home, corporation, building or structure.	
'792 Claim 8 CC1	
8. The water use monitoring and leak detection apparatus of claim 1, further comprising automatic learning mode whereby learning software privately tracks an owner's water flow and volume use for a period, assigning water patterns and water signatures to each specific water use device.	

'792 Claim 9 CC1	
9. The water use monitoring and leak detection apparatus of claim 2, further comprising a water use calibration mode for learning the patterns and signature of water use devices within a home, corporation, building or structure.	
'792 Claim 10 CC1	
10. The water use monitoring and leak detection apparatus of claim 2, further comprising automatic learning mode whereby learning software privately tracks an owner's water flow and volume use for a period, assigning water patterns and water signatures to each specific water use device.	
'792 Claim 12 CC1	
12. The water use monitoring and leak detection apparatus of claim 1, further comprising a water control means or a variable water flow means, said water control means or variable water flow means ~~is~~ controlled by programming instructions from said microprocessor or microcontroller for turning on and off said water control means or setting a variable water flow means, said water control means or variable water flow means can be activated by an owner's or user's cell phone, smart phones, ~~or~~ mobile phone, or other mobile electronic communication device, or by a remote apparatus or computer or alternately activated by said one or more wireless or wired means controlled by a municipality or governmental agency.	Abstract - A shut off valve can be triggered remotely when a request is received from the user, which closes the water pipeline to prevent water damage. Col. 5, lines 10-24 - … the system 8 includes shut off valves 58, 68, and 78 at respective pipelines 50, 60 and 70. The central controller 10 may receive input from the user or homeowner in response to the warning or message, and the user, for example, may respond with instructions to shut off the pipelines 50, 60, and/or 70 via the respective shut off valve 58, 68 and 78.
'792 Claim 14 CC1	
14. The water use monitoring and leak detection apparatus of claim 2, further comprising a water shut control means or a variable water flow means, said water control means or variable water flow means controlled by programming instructions from said microprocessor or microcontroller for turning on and off said water control means or setting a variable water flow means, said water control means or variable water flow means can be activated by an owner's or user's cell phone, smart phones, mobile phone, or other mobile electronic communication device, or by a remote apparatus or computer or alternately activated by said one or more wireless or wired means controlled by a municipality or governmental agency.	Abstract - A shut off valve can be triggered remotely when a request is received from the user, which closes the water pipeline to prevent water damage. Col. 5, lines 10-24 - … the system 8 includes shut off valves 58, 68, and 78 at respective pipelines 50, 60 and 70. The central controller 10 may receive input from the user or homeowner in response to the warning or message, and the user, for example, may respond with instructions to shut off the pipelines 50, 60, and/or 70 via the respective shut off valve 58, 68 and 78.

'792 Claim 17 CC1	
17. The water use monitoring and leak detection apparatus of claim 1, wherein the base station can be incorporated into or serve as the pressure regulator or primary water meter at a residential home or commercial facility.	Col. 3, line 36-40 - A main water meter 52 is operatively connected to the main water inlet pipe 50 for measuring a total amount of water flow into the home and communicating information gathered to the controller 10 via a communication module 56. **(But no disclosure of a pressure regulator)**
'792 Claim 19 CC1	
19. The water use monitoring and leak detection apparatus of claim 2, wherein the base station can be incorporated into or serve as the pressure regulator or primary water meter at a residential home or commercial facility.	Col. 3, line 36-40 - A main water meter 52 is operatively connected to the main water inlet pipe 50 for measuring a total amount of water flow into the home and communicating information gathered to the controller 10 via a communication module 56. **(But no disclosure of a pressure regulator)**
'792 Claim 23 CC1	
23. The water use monitoring and leak detection apparatus of claim 2, further comprising said base station including an electronic water control valve wherein said base station is programmed to automatically turns off the main water supply when a leak is detected or alternately can send an alert signal when a leak is detected to ~~a~~ said cell phone, smart phone, mobile phone, or other mobile electronic communication device whereby a user is provided an election to send a command to the base station to control the electronic water control valve to turn off or leave on the main water supply.	
'792 Claim 28 CC1	
28. The water use monitoring apparatus of claim 1, further compromising one or more pressure sensors, said one or more pressure sensors in electrical connection with said first electrical circuity.	
'792 Claim 29 CC1	
29. The water use monitoring and leak detection apparatus of claim 1, further compromising one or more temperature sensors, said one or more temperature sensors in electrical connection with said first electrical circuity.	
'792 Claim 31 CC1	
31. The water use monitoring and leak detection apparatus of claim 2, further comprising one or more pressure sensors, said one or more pressure sensors in electrical connection with said first electrical circuity.	

'792 Claim 32 CC1	
32. The water use monitoring and leak detection apparatus of claim 2, further comprising one or more temperature sensors, said one or more temperature sensors in electrical connection with said first electrical circuity.	

CC2

US. Patent 9,749,792 Claim Chart - Palayur 2011/0035063

'792 Claim 1 CC2	
A water use and monitoring and leak detection apparatus comprising:	Abstract - This invention is a water consumption monitoring and control system comprised of a base unit, itself comprising a display and a data entry device, a microprocessor, a communication link to water meters, pressure sensors, temperature sensors, flush toilet vibration sensors and shut-off valves. In addition, the base unit has access to the Internet and can access a server which holds a database of water conservation information.
a base station designed to be connected to a main water supply means;	Abstract - This invention is a water consumption monitoring and control system comprised of a base unit.
said base station includes a joint means for connecting to a cold/ambient water supply, or a joint means for connecting to a cold/ambient water supply and a joint means for connecting to a hot water supply, said base station have a joint means for connecting to outgoing water supply line(s) for a home residence, company or building structure;	
electrical circuitry including one or more microprocessors or microcontrollers with a power source contained with said base station apparatus;	Paragraph 0054 – … it comprises a microcontroller 21, a display 21, a data entry device 22 and at least one communication link 23.
said power source is either AC powered, DC powered, or powered with one or more batteries, said power source is electrically connected to said electrical circuitry;	
one or more flow sensors in communication with a water supply, said one or more flow sensors in electrical communication with said electrical circuitry;	Paragraph 0048 - A series of sensors including water temperature sensors 3, water pressure sensors 8, floor moisture sensors 7, vibration flush sensors 5, water meters 2, 4, rain sensors/gauge 16.

one or more wired or wireless electrical communication means, said or wired wireless electrical communication means having the capability to transfer water parameter, water energy and/or water quality information or data to one or more remote apparatuses, said wired or wireless electrical communication means utilizes protection technology to securely provide water use, water energy and/or water quality information and/or data in a confidential format;	Fig. 1, 2 and 4, Paragraphs 0007… through the internet, with a server, Paragraph 0055 - The communication links 23 can include communication from the sensors to the actuators. This communication can be implemented by means of a wire or wirelessly for example, by means of ISM band transceivers, Zigbee or WiFi. The communication also includes access to the Internet, either wirelessly, or by means of a wired ethernet. irrigation sprinklers from the utility company. Paragraph 0084 …the Internet server 9 also communicates with the water company server 14. Paragraph 0088. . . FIG. 1, the Internet server 9 obtains weather information 15 from the national climate data center currently located at www.ncdc.noaa.gov . . Paragraph 0090 - government mandated watering schedule is also used by the server 9 to calculate watering schedules . . . Paragraph 0091 internet server can also communicate with the water company to retrieve water usage rates, discount or overcharge hours, water quality advisories. **Does not disclose transferring water use data in a confidential format.**
said base station includes mesh-enabled circuitry that can communicate with other base stations for transferring water flow, water energy and/or water quality data;	
said base station(s) functioning as one or more access points that transfer said water flow, water energy and/or water quality data, using encryption and identification technology to an internet connection;	
said water flow, water energy and/or water quality data transferred over the internet connection to one or more remote computers or computer servers, and;	
said remote computers or servers allow registered owners and users to access their registered water flow, water energy and/or water quality data using a cell phone, smart phone, mobile phone, or a mobile electronic communication device.	

'792 Claim 2 CC2	
a base station in close proximity to a main water supply;	Abstract - This invention is a water consumption monitoring and control system comprised of a base unit, itself comprising a display and a data entry device, a microprocessor, a communication link to water meters, pressure sensors, temperature sensors, flush toilet vibration sensors and shut-off valves. In addition, the base unit has access to the Internet and can access a server which holds a database of water conservation information.
said base station includes a joint means for connecting to a cold/ambient water supply, or a joint means for connecting to a cold/ambient water supply and a joint means for connecting to a hot water supply, said base station have a joint means for connecting to outgoing water supply line(s) for a home residence, company or building structure;	Abstract - This invention is a water consumption monitoring and control system comprised of a base unit.
said base station further comprising a first power supply, said first power supply is either AC powered, DC powered, or powered with one or more batteries, said first power supply electrically connected to a first circuitry which has one or more microprocessors or microcontrollers;	Fig. 2, Paragraph 0008 … includes a microprocessor…, 0044 The microprocessor in the base unit… 0054 … it comprises a microcontroller 21, a display 21, a data entry device 22 and at least one communication link 23.
one or more water flow sensors in communication with a water supply, said one or more water flow sensors in electrical connection with a first electrical circuity;	Paragraph 0048 - A series of sensors including water temperature sensors 3, water pressure sensors 8, floor moisture sensors 7, vibration flush sensors 5, water meters 2, 4, rain sensors/gauge 16.
said base station monitors and processes water parameter data including water flow, water energy, and/or water quality data;	
said base station includes software that controls and sequences the water parameter data and prepares said data for wired or wireless transfer;	
a receiving station, said receiving station having a second electrical circuitry including one or more second microprocessors, said receiving station remotely located from said base station;	

said receiving station having a second power supply, said second power supply is either AC power, DC power, or powered with one or more batteries, said second power supply electrically connected to a second circuitry;	
said first electrical circuitry of said base station is in wire or wireless communication with said second electrical circuity of said receiving station;	
said receiving station designed to establish Wi-Fi, Bluetooth or ZigBee electrical communication with a wireless router/server, and/or cellular communication with a cell tower technology, and any combinations thereof;	
said receiving station includes mesh-enabled circuitry that can communicate with other receiving stations for transferring water flow, water energy and/or water quality data to one or more access points;	
said receiving station or a custom transfer apparatus functioning as one or more access points for transferring said water flow, water energy and/or water quality data over an internet connection to one or more remote computers or computer servers; and	
said computer servers allow registered owners and users to access their registered water flow, water energy and/or water quality data using a cell phone, smart phone, mobile phone or a mobile electronic communication device.	
'792 Claim 5 CC2	
5. The water use monitoring and leak detection apparatus of claim 1, further comprising said base station including an electronic water control valve wherein said base station is programmed to automatically turns off the main water supply when a leak is detected or alternately can send an alert signal when a leak is detected to ~~a~~ said cell phone, smart phone, mobile phone, or other mobile electronic communication device wherein a user is provided an election to send a command to the base station to control the electronic water control valve to turn off or leave on the main water supply.	Abstract - A shut off valve can be triggered remotely when a request is received from the user, which closes the water pipeline to prevent water damage. Col. 5, lines 10-24 - … the system 8 includes shut off valves 58, 68, and 78 at respective pipelines 50, 60 and 70. The central controller 10 may receive input from the user or homeowner in response to the warning or message, and the user, for example, may respond with instructions to shut off the pipelines 50, 60, and/or 70 via the respective shut off valve 58, 68 and 78

'792 Claim 7 CC2	
7. The water use monitoring and leak detection apparatus of claim 1, further comprising a water use calibration mode for learning the patterns and signature of water use devices within a home, corporation, building or structure.	
'792 Claim 8 CC2	
8. The water use monitoring and leak detection apparatus of claim 1, further comprising automatic learning mode whereby learning software privately tracks an owner's water flow and volume use for a period, assigning water patterns and water signatures to each specific water use device.	
'792 Claim 9 CC2	
9. The water use monitoring and leak detection apparatus of claim 2, further comprising a water use calibration mode for learning the patterns and signature of water use devices within a home, corporation, building or structure.	
'792 Claim 10 CC2	
10. The water use monitoring and leak detection apparatus of claim 2, further comprising automatic learning mode whereby learning software privately tracks an owner's water flow and volume use for a period, assigning water patterns and water signatures to each specific water use device.	
'792 Claim 12 CC2	
12. The water use monitoring and leak detection apparatus of claim 1, further comprising a water control means or a variable water flow means, said water control means or variable water flow means ~~is~~ controlled by programming instructions from said microprocessor or microcontroller for turning on and off said water control means or setting a variable water flow means, said water control means or variable water flow means can be activated by an owner's or user's cell phone, smart phones, ~~or~~ mobile phone, or other mobile electronic communication device, or by a remote apparatus or computer or alternately activated by said one or more wireless or wired means controlled by a municipality or governmental agency.	Abstract - A shut off valve can be triggered remotely when a request is received from the user, which closes the water pipeline to prevent water damage. Col. 5, lines 10-24 - … the system 8 includes shut off valves 58, 68, and 78 at respective pipelines 50, 60 and 70. The central controller 10 may receive input from the user or homeowner in response to the warning or message, and the user, for example, may respond with instructions to shut off the pipelines 50, 60, and/or 70 via the respective shut off valve 58, 68 and 78.

'792 Claim 14 CC2	
14. The water use monitoring and leak detection apparatus of claim 2, further comprising a water shut control means or a variable water flow means, said water control means or variable water flow means controlled by programming instructions from said microprocessor or microcontroller for turning on and off said water control means or setting a variable water flow means, said water control means or variable water flow means can be activated by an owner's or user's cell phone, smart phones, mobile phone, or other mobile electronic communication device, or by a remote apparatus or computer or alternately activated by said one or more wireless or wired means controlled by a municipality or governmental agency.	
'792 Claim 17 CC2	
17. The water use monitoring and leak detection apparatus of claim 1, wherein the base station can be incorporated into or serve as the pressure regulator or primary water meter at a residential home or commercial facility.	Abstract - Methods and systems are disclosed for monitoring water leaks within a home. A home network with various devices monitors these devices with a controller.
'792 Claim 19 CC2	
19. The water use monitoring and leak detection apparatus of claim 2, wherein the base station can be incorporated into or serve as the pressure regulator or primary water meter at a residential home or commercial facility.	
'792 Claim 23 CC2	
23. The water use monitoring and leak detection apparatus of claim 2, further comprising said base station including an electronic water control valve wherein said base station is programmed to automatically turns off the main water supply when a leak is detected or alternately can send an alert signal when a leak is detected to ~~a~~ said cell phone, smart phone, mobile phone, or other mobile electronic communication device whereby a user is provided an election to send a command to the base station to control the electronic water control valve to turn off or leave on the main water supply.	
'792 Claim 28 CC2	
28. The water use monitoring apparatus of claim 1, further compromising one or more pressure sensors, said one or more pressure sensors in electrical connection with said first electrical circuity.	Fig. 5, Paragraphs 16, 33, 34, 35, 36, 44, 48, 68, and 76.

'792 Claim 29 CC2	
29. The water use monitoring and leak detection apparatus of claim 1, further compromising one or more temperature sensors, said one or more temperature sensors in electrical connection with said first electrical circuity.	Fig. 5, Paragraphs 15, 40, 44, 48, 68, 75, and 81
'792 Claim 31 CC2	
31. The water use monitoring and leak detection apparatus of claim 2, further comprising one or more pressure sensors, said one or more pressure sensors in electrical connection with said first electrical circuity.	
'792 Claim 32 CC2	
32. The water use monitoring and leak detection apparatus of claim 2, further comprising one or more temperature sensors, said one or more temperature sensors in electrical connection with said first electrical circuity.	

<u>CC3</u>

US. Patent 9,749,792 Claim Chart - Broniak 9,019,120 in view of Palayur 2011/0035063

'792 Claim 1 CC3	
A water parameter use and monitoring apparatus comprising:	'120 Abstract - Methods and systems are disclosed for monitoring water leaks within a home. A home network with various devices monitors these devices with a controller. '063 Abstract - This invention is a water consumption monitoring and control system comprised of a base unit, itself comprising a display and a data entry device, a microprocessor, a communication link to water meters, pressure sensors, temperature sensors, flush toilet vibration sensors and shut-off valves. In addition, the base unit has access to the Internet and can access a server which holds a database of water conservation information.
A base station apparatus designed to be connected to a main water supply means;	'120 Col. 3, line 36-40 - A main water meter 52 is operatively connected to the main water inlet pipe 50 for measuring a total amount of water flow into the home and communicating information gathered to the controller 10 via a communication module 56. '063 Abstract - This invention is a water consumption monitoring and control system comprised of a base unit.
said base station includes a joint means for connecting to a cold/ambient water supply, or a joint means for connecting to a cold/ambient water supply and a joint means for connecting to a hot water supply, said base station have a joint means for connecting to outgoing water supply line(s) for a home residence, company or building structure;	'120 Col. 3, line 36-40 - A main water meter 52 is operatively connected to the main water inlet pipe 50 for measuring a total amount of water flow into the home,
electrical circuitry including one or more microprocessors or microcontrollers with a power source contained with said base station apparatus;	'120 Col. 2, lines 60-67 - The controller 10 includes a microprocessor, which is programmed to selectively send and/or receive signals to a device control board 24 and 26 of devices 12 and 14, for example, in response to the input signal it receives. Fig. 2, Paragraph 0008 … includes a microprocessor…, 0044 The microprocessor in the base unit… 0054 … it comprises a microcontroller 21, a display 21, a data entry device 22 and at least one communication link 23.

said power source is either AC powered, DC powered, or powered with one or more batteries, said power source is electrically connected to said electrical circuitry;	
one or more flow sensors in communication with a water supply, said one or more flow sensors in electrical communication with said electrical circuitry;	'120 Col.3, lines 52-55 - … includes at least one water meter or flow meter for measuring water that is consumed by a water consuming device and communicating information gathered to the controller 10 via a communication module 56. '063 Paragraph 0048 - A series of sensors including water temperature sensors 3, water pressure sensors 8, floor moisture sensors 7, vibration flush sensors 5, water meters 2, 4, rain sensors/gauge 16.
one or more wired or wireless electrical communication means, said or wired wireless electrical communication means having the capability to transfer water parameter, water energy and/or water quality information or data to one or more remote apparatuses, said wired or wireless electrical communication means utilizes protection technology to securely provide water use, water energy and/or water quality information and/or data in a confidential format;	'063, Fig. 1, 2 and 4, Paragraphs 0007, 0008, 0010, 0068-0069
said base station includes mesh-enabled circuitry that can communicate with other base stations for transferring water flow, water energy and/or water quality data;	
said base station(s) functioning as one or more access points that transfer said water flow, water energy and/or water quality data, using encryption and identification technology to an internet connection;	Neither '120, nor '063 disclose any access point transfer neither any encryption or identification technology to an internet connection.
said water flow, water energy and/or water quality data transferred over the internet connection to one or more remote computers or computer servers, and;	
said remote computers or servers allow registered owners and users to access their registered water flow, water energy and/or water quality data using a cell phone, smart phone, mobile phone, or a mobile electronic communication device.	Neither '120, nor '063 disclose any means to allow registered owners and users to access their registered water flow, water energy and/or water quality data using a cell phone, smart phone, ~~or~~ mobile phone, or a mobile electronic communication device.
'792 Claim 2 CC3	
a base station in close proximity to a main water supply;	'120 Abstract - Methods and systems are disclosed for monitoring water leaks within a home. A home network with various devices monitors these devices with a controller. '063 Abstract – This invention is a water consumption monitoring and control system

	comprised of a base unit, itself compromising a display and data entry device, a microprocessor, a communication like to water meters, pressure sensors, temperature sensors and shut off valve. In addition, the base unit has access to the Internet and can access a server which holds a database of water conservation information. The database includes watering advisories from local government, and weather information from the weather office.
said base station includes a joint means for connecting to a cold/ambient water supply, or a joint means for connecting to a cold/ambient water supply and a joint means for connecting to a hot water supply, said base station have a joint means for connecting to outgoing water supply line(s) for a home residence, company or building structure;	'120 Col. 3, line 36-40 - A main water meter 52 is operatively connected to the main water inlet pipe 50 for measuring a total amount of water flow into the home and communicating information gathered to the controller 10 via a communication module 56. '063 Col. 3, line 36-40 - A main water meter 52 is operatively connected to the main water inlet pipe 50 for measuring a total amount of water flow into the home.
said base station further comprising a first power supply, said first power supply is either AC powered, DC powered, or powered with one or more batteries, said first power supply electrically connected to a first circuitry which has one or more microprocessors or microcontrollers;	'120 Col. 2, lines 60-67 - The controller 10 includes a microprocessor, which is programmed to selectively send and/or receive signals to a device control board 24 and 26 of devices 12 and 14, for example, in response to the input signal it receives. '063 Fig. 2, Paragraph 0008 … includes a microprocessor…, 0044 The microprocessor in the base unit… 0054 … it comprises a microcontroller 21, a display 21, a data entry device 22 and at least one communication link 23.
one or more water flow sensors in communication with a water supply, said one or more water flow sensors in electrical connection with a first electrical circuity;	'120 Col.3, lines 52-55 - … includes at least one water meter or flow meter for measuring water that is consumed by a water consuming device and communicating information gathered to the controller 10 via a communication module 56. '063 Paragraph 0048 - A series of sensors including water temperature sensors 3, water pressure sensors 8, floor moisture sensors 7, vibration flush sensors 5, water meters 2, 4, rain sensors/gauge 16.
said base station monitors and processes water parameter data including water flow, water energy, and/or water quality data;	

a receiving station, said receiving station having a second electrical circuitry including one or more second microprocessors, said receiving station remotely located from said base station;	
said base station includes software that controls and sequences the water parameter data and prepares said data for wired or wireless transfer;	
said receiving station having a second power supply, said second power supply is either AC power, DC power, or powered with one or more batteries, said second power supply electrically connected to a second circuitry;	
said first electrical circuitry of said base station is in wire or wireless communication with said second electrical circuity of said receiving station;	
said receiving station designed to establish Wi-Fi, Bluetooth or ZigBee electrical communication with a wireless router/server, and/or cellular communication with a cell tower technology, and any combinations thereof;	
said receiving station includes mesh-enabled circuitry that can communicate with other receiving stations for transferring water flow, water energy and/or water quality data to one or more access points;	
said receiving station or a custom transfer apparatus functioning as one or more access points for transferring said water flow, water energy and/or water quality data over an internet connection to one or more remote computers or computer servers; and	
said computer servers allow registered owners and users to access their registered water flow, water energy and/or water quality data using a cell phone, smart phone, mobile phone or a mobile electronic communication device.	

'792 Claim 5, CC3	
5. The water use monitoring and leak detection apparatus of claim 1, further comprising said base station including an electronic water control valve wherein said base station is programmed to automatically turns off the main water supply when a leak is detected or alternately can send an alert signal when a leak is detected to ~~a~~ said cell phone, smart phone, mobile phone, or other mobile electronic communication device wherein a user is provided an election to send a command to the base station to control the electronic water control valve to turn off or leave on the main water supply.	'120 Abstract - A shut off valve can be triggered remotely when a request is received from the user, which closes the water pipeline to prevent water damage. Col. 5, lines 10-24 - … the system 8 includes shut off valves 58, 68, and 78 at respective pipelines 50, 60 and 70. The central controller 10 may receive input from the user or homeowner in response to the warning or message, and the user, for example, may respond with instructions to shut off the pipelines 50, 60, and/or 70 via the respective shut off valve 58, 68 and 78. '063 Abstract – This invention is a water consumption monitoring and control system comprised of a base unit, itself compromising a display and data entry device, a microprocessor, a communication like to water meters, pressure sensors, temperature sensors and shut off valve. In addition, the base unit has access to the Internet and can access a server which holds a database of water conservation information. The database includes watering advisories from local government, and weather information from the weather office.
'792 Claim 7 CC3	
7. The water use monitoring and leak detection apparatus of claim 1, further comprising a water use calibration mode for learning the patterns and signature of water use devices within a home, corporation, building or structure.	
'792 Claim 8 CC3	
8. The water use monitoring and leak detection apparatus of claim 1, further comprising automatic learning mode whereby learning software privately tracks an owner's water flow and volume use for a period, assigning water patterns and water signatures to each specific water use device.	

'792 Claim 9 CC3	
9. The water use monitoring and leak detection apparatus of claim 2, further comprising a water use calibration mode for learning the patterns and signature of water use devices within a home, corporation, building or structure.	
'792 Claim 10 CC3	
10. The water use monitoring and leak detection apparatus of claim 2, further comprising automatic learning mode whereby learning software privately tracks an owner's water flow and volume use for a period, assigning water patterns and water signatures to each specific water use device.	
'792 Claim 12 CC3	
12. The water use monitoring and leak detection apparatus of claim 1, further comprising a water control means or a variable water flow means, said water control means or variable water flow means ~~is~~ controlled by programming instructions from said microprocessor or microcontroller for turning on and off said water control means or setting a variable water flow means, said water control means or variable water flow means can be activated by an owner's or user's cell phone, smart phones, mobile phone, or other mobile electronic communication device, or by a remote apparatus or computer or alternately activated by said one or more wireless or wired means controlled by a municipality or governmental agency.	'120 Abstract - A shut off valve can be triggered remotely when a request is received from the user, which closes the water pipeline to prevent water damage. Col. 5, lines 10-24 - … the system 8 includes shut off valves 58, 68, and 78 at respective pipelines 50, 60 and 70. The central controller 10 may receive input from the user or homeowner in response to the warning or message, and the user, for example, may respond with instructions to shut off the pipelines 50, 60, and/or 70 via the respective shut off valve 58, 68 and 78. '063 Abstract – This invention is a water consumption monitoring and control system comprised of a base unit, itself compromising a display and data entry device, a microprocessor, a communication like to water meters, pressure sensors, temperature sensors and shut off valve. In addition, the base unit has access to the Internet and can access a server which holds a database of water conservation information. The database includes watering advisories from local government, and weather information from the weather office.

792 Claim 14 CC3	
14. The water use monitoring and leak detection apparatus of claim 2, further comprising a water shut control means or a variable water flow means, said water control means or variable water flow means controlled by programming instructions from said microprocessor or microcontroller for turning on and off said water control means or setting a variable water flow means, said water control means or variable water flow means can be activated by an owner's or user's cell phone, smart phones, mobile phone, or other mobile electronic communication device, or by a remote apparatus or computer or alternately activated by said one or more wireless or wired means controlled by a municipality or governmental agency.	
'792 Claim 17 CC3	
17. The water use monitoring and leak detection apparatus of claim 1, wherein the base station can be incorporated into or serve as the pressure regulator or primary water meter at a residential home or commercial facility.	
'792 Claim 19 CC3	
19. The water use monitoring and leak detection apparatus of claim 2, wherein the base station can be incorporated into or serve as the pressure regulator or primary water meter at a residential home or commercial facility.	
'792 Claim 23 CC3	
23. The water use monitoring and leak detection apparatus of claim 2, further comprising said base station including an electronic water control valve wherein said base station is programmed to automatically turns off the main water supply when a leak is detected or alternately can send an alert signal when a leak is detected to said cell phone, smart phone, mobile phone, or other mobile electronic communication device whereby a user is provided an election to send a command to the base station to control the electronic water control valve to turn off or leave on the main water supply.	
'792 Claim 28 CC3	
28. The water use monitoring apparatus of claim 1, further compromising one or more pressure sensors, said one or more pressure sensors in electrical connection with said first electrical circuity.	Paragraph 0048 - A series of sensors including water temperature sensors 3, water pressure sensors 8, floor moisture sensors 7, vibration flush sensors 5, water meters 2, 4, rain sensors/gauge 16.

'792 Claim 29 CC3	
29. The water use monitoring and leak detection apparatus of claim 1, further compromising one or more temperature sensors, said one or more temperature sensors in electrical connection with said first electrical circuity.	Paragraph 0048 - A series of sensors including water temperature sensors 3, water pressure sensors 8, floor moisture sensors 7, vibration flush sensors 5, water meters 2, 4, rain sensors/gauge 16.
'792 Claim 31 CC3	
31. The water use monitoring and leak detection apparatus of claim 2, further comprising one or more pressure sensors, said one or more pressure sensors in electrical connection with said first electrical circuity.	
'792 Claim 32 CC3	
32. The water use monitoring and leak detection apparatus of claim 2, further comprising one or more temperature sensors, said one or more temperature sensors in electrical connection with said first electrical circuity.	

CC4

US. Patent 9,749,792 Claim Chart - Ball 8,833,390

'792 Claim 1 CC4	
A water parameter use and monitoring apparatus comprising:	Abstract - A valve meter device, assembly, and method is disclosed including a housing defining at least one inlet opening and at least one outlet opening and a channel connecting the openings, the at least one inlet opening having an inlet end and the at least one outlet opening having an outlet end; a water meter positioned in the channel, the water meter configured to monitor a flow of water through the valve meter device;
A base station apparatus designed to be connected to a main water supply means;	Col. 4, lines 31-33 - As illustrated in FIG. 3, the device housing 110 has an inlet 310 and an outlet 320. Water flows through the device housing 110 by flowing into the inlet 310 and the out of the outlet 320.
said base station includes a joint means for connecting to a cold/ambient water supply, or a joint means for connecting to a cold/ambient water supply and a joint means for connecting to a hot water supply, said base station have a joint means for connecting to outgoing water supply line(s) for a home residence, company or building structure;	Col. 4, lines 31-33 - As illustrated in FIG. 3, the device housing 110 has an inlet 310 and an outlet 320. Water flows through the device housing 110 by flowing into the inlet 310 and the out of the outlet 320.
electrical circuitry including one or more microprocessors or microcontrollers with a power source contained with said base station apparatus;	Col. 11, lines 36-42 - Enclosed within the plastic cover 2320a, b is a sealing gasket 2420, a battery 2430, a transceiver 2440, and a printed circuit board (PCB) 2450. Where a "printed circuit board" or PCB is included in the current description, any circuitry which functions as the PCB is intended to be included in alternative embodiments as a variant of a printed circuit board.
said power source is either AC powered, DC powered, or powered with one or more batteries, said power source is electrically connected to said electrical circuitry;	Col. 11, lines 36-42 - Enclosed within the plastic cover 2320a, b is a sealing gasket 2420, a battery 2430, a transceiver 2440, and a printed circuit board (PCB) 2450. Where a "printed circuit board" or PCB is included in the current description, any circuitry which functions as the PCB is intended to be included in alternative embodiments as a variant of a printed circuit board.
one or more flow sensors in communication with a water supply, said one or more flow sensors in electrical communication with said electrical circuitry;	Col. 10, lines 38-52 - Internal to the meter is a nutating disc 2110 that interfaces with an output register interaction shaft 2120. The nutating disc 2110 includes a disc pin 2115 which engages the output register interaction shaft 2120. In operation, the nutating disc 2110 and disc pin 2115 wobble about a fixed point in the meter to drive the output register interaction shaft 2120. The output register

	interaction shaft 2120 is attached to a meter magnet 2130. The meter magnet 2130 has a four-pole arrangement that coordinates with a register 2220 (shown in FIG. 22) such that when the meter magnet 2130 turns the register 2220 logs the motion and provides a readout of water usage.
one or more wired or wireless electrical communication means, said or wired wireless electrical communication means having the capability to transfer water parameter, water energy and/or water quality information or data to one or more remote apparatuses, said wired or wireless electrical communication means utilizes protection technology to securely provide water use, water energy and/or water quality information and/or data in a confidential format;	Ball monitors water flow but fails to disclose or claim transferring water parameter data to a remote apparatus utilizing a confidential format
said base station includes mesh-enabled circuitry that can communicate with other base stations for transferring water flow, water energy and/or water quality data;	Col. 11, lines 17-22 - The remotely located communicator may be any communication device or system including a computer, a server, a gateway, another valve meter assembly, a handheld device, a mesh network, or any other device or system capable of communicating with the wireless communication unit 2310.
said base station(s) functioning as one or more access points that transfer said water flow, water energy and/or water quality data, using encryption and identification technology to an internet connection;	Col. 11, lines 7-25 - In an embodiment of the valve meter assembly 1000, the wireless communication unit 2310 may receive signals from the remotely located communicator, or send signals to the remotely located communicator, or both. The wireless communication unit 2310 may include a wireless communication unit circuit 2925 (shown in FIG. 29) as part of the PCB 2450. The wireless communication unit circuit 2925 receives signals from the remotely located communicator. Ball fails to disclose any encryption or identification technology to an internet connection.
said water flow, water energy and/or water quality data transferred over the internet connection to one or more remote computers or computer servers, and;	Petitioner contends that Ball fails to disclose transferring water parameter data over the internet to one or more remote computers or computer servers

said remote computers or servers allow registered owners and users to access their registered water flow, water energy and/or water quality data using a cell phone, smart phone, mobile phone, or a mobile electronic communication device	Col. 11, lines 17-22 - The remotely located communicator may be any communication device or system including a computer, a server, a gateway, another valve meter assembly, a handheld device, a mesh network, or any other device or system capable of communicating with the wireless communication unit 2310. But Petitioner contends that Ball fails to disclose allowing owner and users to access their registered water parameter data using a cell phone, smart phone, mobile phone, or a mobile electronic communication device.
'792 Claim 2 CC4	
a base station in close proximity to a main water supply;	
said base station includes a joint means for connecting to a cold/ambient water supply, or a joint means for connecting to a cold/ambient water supply and a joint means for connecting to a hot water supply, said base station have a joint means for connecting to outgoing water supply line(s) for a home residence, company or building structure;	Col. 4, lines 31-33 - As illustrated in FIG. 3, the device housing 110 has an inlet 310 and an outlet 320. Water flows through the device housing 110 by flowing into the inlet 310 and the out of the outlet 320.
said base station further comprising a first power supply, said first power supply is either AC powered, DC powered, or powered with one or more batteries, said first power supply electrically connected to a first circuitry which has one or more microprocessors or microcontrollers;	Col. 11, lines 36-42 - Enclosed within the plastic cover 2320a, b is a sealing gasket 2420, a battery 2430, a transceiver 2440, and a printed circuit board (PCB) 2450. Where a "printed circuit board" or PCB is included in the current description, any circuitry which functions as the PCB is intended to be included in alternative embodiments as a variant of a printed circuit board.
one or more water flow sensors in communication with a water supply, said one or more water flow sensors in electrical connection with a first electrical circuity;	Col. 11, lines 17-22 - The remotely located communicator may be any communication device or system including a computer, a server, a gateway, another valve meter assembly, a handheld device, a mesh network, or any other device or system capable of communicating with the wireless communication unit 2310.
said base station monitors and processes water parameter data including water flow, water energy, and/or water quality data;	

said base station includes software that controls and sequences the water parameter data and prepares said data for wired or wireless transfer;	Fig. 29, Col. 11, lines 12-22 The communication device in some embodiments may be a wireless communication unit 2310. In the current embodiment, the wireless communication unit 2310 is part of a mesh network where the mesh network includes the remotely located communicator. The remotely located communicator may be operated by a municipality, a technician, a service provider, or another entity. The remotely located communicator may be any communication device or system including a computer, a server, a gateway, another valve meter assembly, a handheld device, a mesh network, or any other device or system capable of communicating with the wireless communication unit 2310.
a receiving station, said receiving station having a second electrical circuitry including one or more second microprocessors, said receiving station remotely located from said base station;	Col. 16, lines 17-42, Fig. 29 – The wireless communication unit 2310 may include a wireless communication unit circuit 2925 may be configured to log the status of the solenoid 270.
said receiving station having a second power supply, said second power supply is either AC power, DC power, or powered with one or more batteries, said second power supply electrically connected to a second circuitry;	Col. 16, lines 41-44 – The wireless communication unit 2310 and each register circuit 2910 may be powered by a battery2430.
said first electrical circuitry of said base station is in wire or wireless communication with said second electrical circuity of said receiving station;	Fig. 29, Column 6, lines 41-52, The wireless communication unit 2310 may include a wireless communication unit circuit 2925.
said receiving station designed to establish Wi-Fi, Bluetooth or ZigBee electrical communication with a wireless router/server, and/or cellular communication with a cell tower technology, and any combinations thereof;	
said receiving station includes mesh-enabled circuitry that can communicate with other receiving stations for transferring water flow, water energy and/or water quality data to one or more access points;	Fig. 29, Col. 11, lines 12-22 The communication device in some embodiments may be a wireless communication unit 2310. In the current embodiment, the wireless communication unit 2310 is part of a mesh network where the mesh network includes the remotely located communicator. The remotely located communicator may be operated by a municipality, a technician, a service provider, or another entity. The remotely located communicator may be any communication device or system including a computer, a server, a gateway, another valve meter assembly, a handheld device, a mesh network, or any other device or system capable of

	communicating with the wireless communication unit 2310.
said receiving station or a custom transfer apparatus functioning as one or more access points for transferring said water flow, water energy and/or water quality data over an internet connection to one or more remote computers or computer servers; and	
said computer servers allow registered owners and users to access their registered water flow, water energy and/or water quality data using a cell phone, smart phone, mobile phone or a mobile electronic communication device.	

'792 Claim 5, CC4	
5. The water use monitoring and leak detection apparatus of claim 1, further comprising said base station including an electronic water control valve wherein said base station is programmed to automatically turns off the main water supply when a leak is detected or alternately can send an alert signal when a leak is detected to ~~a~~ said cell phone, smart phone, mobile phone, or other mobile electronic communication device wherein a user is provided an election to send a command to the base station to control the electronic water control valve to turn off or leave on the main water supply.	Col. 3, lines 46-47 - The valve meter device 100 includes a water supply valve 170 and a water meter 210. Col. 8, lines 3-7 - The solenoid attachment portion 820 is dimensioned to define a solenoid chamber 940 between the solenoid 270 and the valve cover 120 when the solenoid 270 is attached to the valve cover 120. Col. 16, lines 21- The wireless communication unit circuit 2925 may be configured to log the status of the solenoid 270. For example, the communication unit circuit 2925 may log whether the solenoid 270 is in the closed or open positon. Petitioner contends that a solenoid valve is not a ball valve design as disclosed and claimed by the present application and thus does not have any capability to perform variable water flow settings.
'792 Claim 7 CC4	
7. The water use monitoring and leak detection apparatus of claim 1, further comprising a water use calibration mode for learning the patterns and signature of water use devices within a home, corporation, building or structure.	
'792 Claim 8 CC4	
8. The water use monitoring and leak detection apparatus of claim 1, further comprising automatic learning mode whereby learning software privately tracks an owner's water flow and volume use for a period, assigning water patterns and water signatures to each specific water use device.	
'792 Claim 9 CC1	
9. The water use monitoring and leak detection apparatus of claim 2, further comprising a water use calibration mode for learning the patterns and signature of water use devices within a home, corporation, building or structure.	
'792 Claim 10 CC1	
10. The water use monitoring and leak detection apparatus of claim 2, further comprising automatic learning mode whereby learning software privately tracks an owner's water flow and volume use for a period, assigning water	

patterns and water signatures to each specific water use device.	
'792 Claim 12 CC1	
12. The water use monitoring and leak detection apparatus of claim 1, further comprising a water control means or a variable water flow means, said water control means or variable water flow means ~~is~~ controlled by programming instructions from said microprocessor or microcontroller for turning on and off said water control means or setting a variable water flow means, said water control means or variable water flow means can be activated by an owner's or user's cell phone, smart phones, ~~or~~ mobile phone, or other mobile electronic communication device, or by a remote apparatus or computer or alternately activated by said one or more wireless or wired means controlled by a municipality or governmental agency.	Col. 3, lines 46-47 - The valve meter device 100 includes a water supply valve 170 and a water meter 210. Col. 8, lines 3-7 - The solenoid attachment portion 820 is dimensioned to define a solenoid chamber 940 between the solenoid 270 and the valve cover 120 when the solenoid 270 is attached to the valve cover 120. Petitioner contends that a solenoid valve is not a ball valve design as disclosed and claimed by the present application and thus does not have any capability to perform variable water flow settings. Also see Ball Col. 16, lines … water supply valve 170 is in a dynamic state between open and closed.
'792 Claim 14 CC1	
14. The water use monitoring and leak detection apparatus of claim 2, further comprising a water shut control means or a variable water flow means, said water control means or variable water flow means controlled by programming instructions from said microprocessor or microcontroller for turning on and off said water control means or setting a variable water flow means, said water control means or variable water flow means can be activated by an owner's or user's cell phone, smart phones, mobile phone, or other mobile electronic communication device, or by a remote apparatus or computer or alternately activated by said one or more wireless or wired means controlled by a municipality or governmental agency.	Col. 3, lines 46-47 - The valve meter device 100 includes a water supply valve 170 and a water meter 210. Col. 8, lines 3-7 - The solenoid attachment portion 820 is dimensioned to define a solenoid chamber 940 between the solenoid 270 and the valve cover 120 when the solenoid 270 is attached to the valve cover 120. Petitioner contends that a solenoid valve is not a ball valve design as disclosed and claimed by the present application and thus does not have any capability to perform variable water flow settings. Also see Ball Col. 16, lines … water supply valve 170 is in a dynamic state between open and closed.
'792 Claim 17 CC1	
17. The water use monitoring and leak detection apparatus of claim 1, wherein the base station can be incorporated into or serve as the pressure regulator or primary water meter at a residential home or commercial facility.	No disclosure in Ball of incorporating a pressure regulator into the water meters.
'792 Claim 19 CC1	
19. The water use monitoring and leak detection apparatus of claim 2, wherein the base station can be incorporated into or serve as the pressure regulator or primary water meter at a residential home or commercial facility.	No disclosure in Ball of incorporating a pressure regulator into the water meters.

'792 Claim 23 CC1	
23. The water use monitoring and leak detection apparatus of claim 2, further comprising said base station including an electronic water control valve wherein said base station is programmed to automatically turns off the main water supply when a leak is detected or alternately can send an alert signal when a leak is detected to ~~a~~ said cell phone, smart phone, mobile phone, or other mobile electronic communication device whereby a user is provided an election to send a command to the base station to control the electronic water control valve to turn off or leave on the main water supply.	Col. 3, lines 46-47 - The valve meter device 100 includes a water supply valve 170 and a water meter 210. Col. 8, lines 3-7 - The solenoid attachment portion 820 is dimensioned to define a solenoid chamber 940 between the solenoid 270 and the valve cover 120 when the solenoid 270 is attached to the valve cover 120. Petitioner contends that Ball does not specifically disclose that the water meter can be programmed to automatically turns off the main water supply when a leak is detected or alternately can send an alert signal when a leak is detected to ~~a~~ said cell phone, smart phone, mobile phone, or other mobile electronic communication device whereby a user is provided an election to send a command to the base station to control the electronic water control valve to turn off or leave on the main water supply.
'792 Claim 28 CC1	
28. The water use monitoring apparatus of claim 1, further compromising one or more pressure sensors, said one or more pressure sensors in electrical connection with said first electrical circuity.	
'792 Claim 29 CC1	
29. The water use monitoring and leak detection apparatus of claim 1, further compromising one or more temperature sensors, said one or more temperature sensors in electrical connection with said first electrical circuity.	
'792 Claim 31 CC1	
31. The water use monitoring and leak detection apparatus of claim 2, further comprising one or more pressure sensors, said one or more pressure sensors in electrical connection with said first electrical circuity.	
'792 Claim 32 CC1	
32. The water use monitoring and leak detection apparatus of claim 2, further comprising one or more temperature sensors, said one or more temperature sensors in electrical connection with said first electrical circuity.	

CC5

US. Patent 9,749,792 Claim Chart - Broniak 9,019,120 in view of Palayur 2011/0035063 and further in view of Ball 8,833,390

'792 Claim 1 CC5	
A water parameter use and monitoring apparatus comprising:	'120 Abstract - Methods and systems are disclosed for monitoring water leaks within a home. A home network with various devices monitors these devices with a controller. '063 Abstract - This invention is a water consumption monitoring and control system comprised of a base unit, itself comprising a display and a data entry device, a microprocessor, a communication link to water meters, pressure sensors, temperature sensors, flush toilet vibration sensors and shut-off valves. In addition, the base unit has access to the Internet and can access a server which holds a database of water conservation information, '390 Abstract - A valve meter device, assembly, and method is disclosed including a housing defining at least one inlet opening and at least one outlet opening and a channel connecting the openings, the at least one inlet opening having an inlet end and the at least one outlet opening having an outlet end; a water meter positioned in the channel, the water meter configured to monitor a flow of water through the valve meter device.
A base station apparatus designed to be connected to a main water supply means;	'120 Col. 3, line 36-40 - A main water meter 52 is operatively connected to the main water inlet pipe 50 for measuring a total amount of water flow into the home and communicating information gathered to the controller 10 via a communication module 56. '063 Abstract - This invention is a water consumption monitoring and control system comprised of a base unit, '390 Col. 4, lines 31-33 - As illustrated in FIG. 3, the device housing 110 has an inlet 310 and an outlet 320. Water flows through the device housing 110 by flowing into the inlet 310 and the out of the outlet 320.
said base station includes a joint means for connecting to a cold/ambient water supply, or a joint means for connecting to a cold/ambient water supply and a joint means for connecting to a hot water supply, said base station have a joint means for connecting to outgoing water supply line(s) for a home residence, company or building structure;	'120 Col. 3, line 36-40 - A main water meter 52 is operatively connected to the main water inlet pipe 50 for measuring a total amount of water flow into the home, '390 Col. 4, lines 31-33 - As illustrated in FIG. 3, the device housing 110 has an inlet 310 and an outlet 320. Water flows through the device housing 110 by flowing into the inlet 310 and the out of the outlet 320.

said apparatus designed to be installed prior to any distribution lines within a residence or commercial building;	'390 Col. 4, lines 46-48 - Water flows into the inlet 310 from a provider or water source and out of the outlet 320 to a home, office building, or other user terminal.
electrical circuitry including one or more microprocessors or microcontrollers with a power source contained with said base station apparatus;	'120 Col. 2, lines 60-67 - The controller 10 includes a microprocessor, which is programmed to selectively send and/or receive signals to a device control board 24 and 26 of devices 12 and 14, for example, in response to the input signal it receives. '063 . . . paragraph 0054 – … it comprises a microcontroller 21, a display 21, a data entry device 22 and at least one communication link 23. '390 Col. 11, lines 36-42 - Enclosed within the plastic cover 2320a, b is a sealing gasket 2420, a battery 2430, a transceiver 2440, and a printed circuit board (PCB) 2450. Where a "printed circuit board" or PCB is included in the current description, any circuitry which functions as the PCB is intended to be included in alternative embodiments as a variant of a printed circuit board.
said power source is either AC powered, DC powered, or powered with one or more batteries, said power source is electrically connected to said electrical circuitry;	'390 Col. 11, lines 36-42 - Enclosed within the plastic cover 2320a, b is a sealing gasket 2420, a battery 2430, a transceiver 2440, and a printed circuit board (PCB) 2450. Where a "printed circuit board" or PCB is included in the current description, any circuitry which functions as the PCB is intended to be included in alternative embodiments as a variant of a printed circuit board.
one or more flow sensors in communication with a water supply, said one or more flow sensors in electrical communication with said electrical circuitry;	'120 Col.3, lines 52-55 - … includes at least one water meter or flow meter for measuring water that is consumed by a water consuming device and communicating information gathered to the controller 10 via a communication module 56. '063 Paragraph 0048 - A series of sensors including water temperature sensors 3, water pressure sensors 8, floor moisture sensors 7, vibration flush sensors 5, water meters 2, 4, rain sensors/gauge 16. ' '390 Col. 11, lines 36-42 - Enclosed within the plastic cover 2320a, b is a sealing gasket 2420, a battery 2430, a transceiver 2440, and a printed circuit board (PCB) 2450. Where a "printed circuit board" or PCB is included in the current description, any circuitry which functions as the PCB is intended to be included in alternative embodiments as a variant of a printed circuit board. 390 Col. 10, lines 38-52 - Internal to the meter is a nutating disc 2110 that interfaces with

	an output register interaction shaft 2120. The nutating disc 2110 includes a disc pin 2115 which engages the output register interaction shaft 2120. In operation, the nutating disc 2110 and disc pin 2115 wobble about a fixed point in the meter to drive the output register interaction shaft 2120. The output register interaction shaft 2120 is attached to a meter magnet 2130. The meter magnet 2130 has a four-pole arrangement that coordinates with a register 2220 (shown in FIG. 22) such that when the meter magnet 2130 turns the register 2220 logs the motion and provides a readout of water usage.
one or more wired or wireless electrical communication means, said or wired wireless electrical communication means having the capability to transfer water parameter, water energy and/or water quality information or data to one or more remote apparatuses, said wired or wireless electrical communication means utilizes protection technology to securely provide water use, water energy and/or water quality information and/or data in a confidential format;	'063, Fig. 1, 2 and 4, Paragraphs 0007, 0008, 0010, 0068-0069 '390 Ball monitors water flow but fails to disclose or claim transferring water parameter data to a remote apparatus utilizing a confidential format
said base station includes mesh-enabled circuitry that can communicate with other base stations for transferring water flow, water energy and/or water quality data;	'390 Col. 11, lines 17-22 - The remotely located communicator may be any communication device or system including a computer, a server, a gateway, another valve meter assembly, a handheld device, a mesh network, or any other device or system capable of communicating with the wireless communication unit 2310.
said base station(s) functioning as one or more access points that transfer said water flow, water energy and/or water quality data, using encryption and identification technology to an internet connection;	'390 Col. 11, lines 7-25 - In an embodiment of the valve meter assembly 1000, the wireless communication unit 2310 may receive signals from the remotely located communicator, or send signals to the remotely located communicator, or both. The wireless communication unit 2310 may include a wireless communication unit circuit 2925 (shown in FIG. 29) as part of the PCB 2450. The wireless communication unit circuit 2925 receives signals from the remotely located communicator. Neither '120, '063, or '390 disclose any access points nor any encryption or identification technology to an internet connection.

said water flow, water energy and/or water quality data transferred over the internet connection to one or more remote computers or computer servers, and;	'390 Col. 11, lines 17-22 - The remotely located communicator may be any communication device or system including a computer, a server, a gateway, another valve meter assembly, a handheld device, a mesh network, or any other device or system capable of communicating with the wireless communication unit 2310.
said remote computers or servers allow registered owners and users to access their registered water flow, water energy and/or water quality data using a cell phone, smart phone, mobile phone, or a mobile electronic communication device.	Neither '120, '063, or '390 disclose any means to allow registered owners and users to access their registered water flow, water energy and/or water quality data using a cell phone, smart phone, ~~or~~ mobile phone, or a mobile electronic communication device.
'792 Claim 2 CC5	
a base station in close proximity to a main water supply;	'120 Abstract - Methods and systems are disclosed for monitoring water leaks within a home. A home network with various devices monitors these devices with a controller. '063 Abstract – This invention is a water consumption monitoring and control system comprised of a base unit, itself compromising a display and data entry device, a microprocessor, a communication like to water meters, pressure sensors, temperature sensors and shut off valve. In addition, the base unit has access to the Internet and can access a server which holds a database of water conservation information. The database includes watering advisories from local government, and weather information from the weather office. '390 Abstract - A valve meter device, assembly, and method is disclosed including a housing defining at least one inlet opening and at least one outlet opening and a channel connecting the openings, the at least one inlet opening having an inlet end and the at least one outlet opening having an outlet end; a water meter positioned in the channel, the water meter configured to monitor a flow of water through the valve meter device.
said base station includes a joint means for connecting to a cold/ambient water supply, or a joint means for connecting to a cold/ambient water supply and a joint means for connecting to a hot water supply, said base station have a joint means for connecting to outgoing water supply line(s) for a home residence, company or building structure;	'120 Col. 3, line 36-40 - A main water meter 52 is operatively connected to the main water inlet pipe 50 for measuring a total amount of water flow into the home and communicating information gathered to the controller 10 via a communication module 56. '063 Col. 3, line 36-40 - A main water meter 52 is operatively connected to the main water inlet pipe 50 for measuring a total amount of water flow into the home

	'390 Col. 4, lines 31-33 - As illustrated in FIG. 3, the device housing 110 has an inlet 310 and an outlet 320. Water flows through the device housing 110 by flowing into the inlet 310 and the out of the outlet 320.
said base station further comprising a first power supply, said first power supply is either AC powered, DC powered, or powered with one or more batteries, said first power supply electrically connected to a first circuitry which has one or more microprocessors or microcontrollers;	'120 Col. 2, lines 60-67 - The controller 10 includes a microprocessor, which is programmed to selectively send and/or receive signals to a device control board 24 and 26 of devices 12 and 14, for example, in response to the input signal it receives. '063 Col. 2, lines 60-67 - The controller 10 includes a microprocessor, which is programmed to selectively send and/or receive signals to a device control board 24 and 26 of devices 12 and 14, for example, in response to the input signal it receives. '390 Col. 11, lines 36-42 - Enclosed within the plastic cover 2320a, b is a sealing gasket 2420, a battery 2430, a transceiver 2440, and a printed circuit board (PCB) 2450. Where a "printed circuit board" or PCB is included in the current description, any circuitry which functions as the PCB is intended to be included in alternative embodiments as a variant of a printed circuit board.
one or more water flow sensors in communication with a water supply, said one or more water flow sensors in electrical connection with a first electrical circuity;	'120 Col.3, lines 52-55 - … includes at least one water meter or flow meter for measuring water that is consumed by a water consuming device and communicating information gathered to the controller 10 via a communication module 56. '063 Paragraph 0048 - A series of sensors including water temperature sensors 3, water pressure sensors 8, floor moisture sensors 7, vibration flush sensors 5, water meters 2, 4, rain sensors/gauge 16. ' '390 Col. 11, lines 36-42 - Enclosed within the plastic cover 2320a, b is a sealing gasket 2420, a battery 2430, a transceiver 2440, and a printed circuit board (PCB) 2450. Where a "printed circuit board" or PCB is included in the current description, any circuitry which functions as the PCB is intended to be included in alternative embodiments as a variant of a printed circuit board. 390 Col. 10, lines 38-52 - Internal to the meter is a nutating disc 2110 that interfaces with an output register interaction shaft 2120. The nutating disc 2110 includes a disc pin 2115 which engages the output register interaction shaft 2120. In operation, the nutating disc 2110 and disc pin 2115 wobble about a fixed point in the meter to

	drive the output register interaction shaft 2120. The output register interaction shaft 2120 is attached to a meter magnet 2130. The meter magnet 2130 has a four-pole arrangement that coordinates with a register 2220 (shown in FIG. 22) such that when the meter magnet 2130 turns the register 2220 logs the motion and provides a readout of water usage.
said base station monitors and processes water parameter data including water flow, water energy, and/or water quality data;	
said base station includes software that controls and sequences the water parameter data and prepares said data for wired or wireless transfer;	'390 Fig. 29, Col. 11, lines 12-22 The communication device in some embodiments may be a wireless communication unit 2310. In the current embodiment, the wireless communication unit 2310 is part of a mesh network where the mesh network includes the remotely located communicator. The remotely located communicator may be operated by a municipality, a technician, a service provider, or another entity. The remotely located communicator may be any communication device or system including a computer, a server, a gateway, another valve meter assembly, a handheld device, a mesh network, or any other device or system capable of communicating with the wireless communication unit 2310.
a receiving station, said receiving station having a second electrical circuitry including one or more second microprocessors, said receiving station remotely located from said base station;	
said receiving station having a second power supply, said second power supply is either AC power, DC power, or powered with one or more batteries, said second power supply electrically connected to a second circuitry;	
said first electrical circuitry of said base station is in wire or wireless communication with said second electrical circuity of said receiving station;	
said receiving station designed to establish Wi-Fi, Bluetooth or ZigBee electrical communication with a wireless router/server, and/or cellular communication with a cell tower technology, and any combinations thereof;	

said receiving station includes mesh-enabled circuitry that can communicate with other receiving stations for transferring water flow, water energy and/or water quality data to one or more access points;	
said receiving station or a custom transfer apparatus functioning as one or more access points for transferring said water flow, water energy and/or water quality data over an internet connection to one or more remote computers or computer servers; and	
said computer servers allow registered owners and users to access their registered water flow, water energy and/or water quality data using a cell phone, smart phone, mobile phone or a mobile electronic communication device.	
'792 Claim 5, CC5	
5. The water use monitoring and leak detection apparatus of claim 1, further comprising said base station including an electronic water control valve wherein said base station is programmed to automatically turns off the main water supply when a leak is detected or alternately can send an alert signal when a leak is detected to ~~a~~ said cell phone, smart phone, mobile phone, or other mobile electronic communication device wherein a user is provided an election to send a command to the base station to control the electronic water control valve to turn off or leave on the main water supply.	'120 Abstract - A shut off valve can be triggered remotely when a request is received from the user, which closes the water pipeline to prevent water damage. Col. 5, lines 10-24 - … the system 8 includes shut off valves 58, 68, and 78 at respective pipelines 50, 60 and 70. The central controller 10 may receive input from the user or homeowner in response to the warning or message, and the user, for example, may respond with instructions to shut off the pipelines 50, 60, and/or 70 via the respective shut off valve 58, 68 and 78 '063 Abstract – This invention is a water consumption monitoring and control system comprised of a base unit, itself compromising a display and data entry device, a microprocessor, a communication like to water meters, pressure sensors, temperature sensors and shut off valve. In addition, the base unit has access to the Internet and can access a server which holds a database of water conservation information. The database includes watering advisories from local government, and weather information from the weather office. '390 Col. 3, lines 46-47 - The valve meter device 100 includes a water supply valve 170 and a water meter 210. Col. 8, lines 3-7 - The solenoid attachment portion 820 is dimensioned to define a solenoid chamber 940 between the solenoid 270 and the valve cover 120 when the solenoid 270 is

	attached to the valve cover 120. Col. 16, lines 21- The wireless communication unit circuit 2925 may be configured to log the status of the solenoid 270. For example, the communication unit circuit 2925 may log whether the solenoid 270 is in the closed or open position. Petitioner contends that a solenoid valve is not a ball valve design as disclosed and claimed by the present application and thus does not have any capability to perform variable water flow settings.
'792 Claim 7 CC5	
7. The water use monitoring and leak detection apparatus of claim 1, further comprising a water use calibration mode for learning the patterns and signature of water use devices within a home, corporation, building or structure.	
'792 Claim 8 CC5	
8. The water use monitoring and leak detection apparatus of claim 1, further comprising automatic learning mode whereby learning software privately tracks an owner's water flow and volume use for a period, assigning water patterns and water signatures to each specific water use device.	
'792 Claim 9 CC5	
9. The water use monitoring and leak detection apparatus of claim 2, further comprising a water use calibration mode for learning the patterns and signature of water use devices within a home, corporation, building or structure.	
'792 Claim 10 CC5	
10. The water use monitoring and leak detection apparatus of claim 2, further comprising automatic learning mode whereby learning software privately tracks an owner's water flow and volume use for a period, assigning water patterns and water signatures to each specific water use device.	
'792 Claim 12 CC5	
12. The water use monitoring and leak detection apparatus of claim 1, further comprising a water control means or a variable water flow means, said water control means or variable water flow means ~~is~~ controlled by programming instructions	Col. 3, lines 46-47 - The valve meter device 100 includes a water supply valve 170 and a water meter 210. Col. 8, lines 3-7 - The solenoid attachment portion 820 is dimensioned to define a solenoid chamber 940 between the solenoid 270

from said microprocessor or microcontroller for turning on and off said water control means or setting a variable water flow means, said water control means or variable water flow means can be activated by an owner's or user's cell phone, smart phones, ~~or~~ mobile phone, or other mobile electronic communication device, or by a remote apparatus or computer or alternately activated by said one or more wireless or wired means controlled by a municipality or governmental agency.	and the valve cover 120 when the solenoid 270 is attached to the valve cover 120. Petitioner contends that a solenoid valve is not a ball valve design as disclosed and claimed by the present application and thus does not have any capability to perform variable water flow settings. Also see Ball Col. 16, lines … water supply valve 170 is in a dynamic state between open and closed.
'792 Claim 14 CC5	
14. The water use monitoring and leak detection apparatus of claim 2, further comprising a water shut control means or a variable water flow means, said water control means or variable water flow means controlled by programming instructions from said microprocessor or microcontroller for turning on and off said water control means or setting a variable water flow means, said water control means or variable water flow means can be activated by an owner's or user's cell phone, smart phones, mobile phone, or other mobile electronic communication device, or by a remote apparatus or computer or alternately activated by said one or more wireless or wired means controlled by a municipality or governmental agency.	
'792 Claim 17 CC5	
17. The water use monitoring and leak detection apparatus of claim 1, wherein the base station can be incorporated into or serve as the pressure regulator or primary water meter at a residential home or commercial facility.	
'792 Claim 19 CC5	
19. The water use monitoring and leak detection apparatus of claim 2, wherein the base station can be incorporated into or serve as the pressure regulator or primary water meter at a residential home or commercial facility.	

'792 Claim 23 CC5	
23. The water use monitoring and leak detection apparatus of claim 2, further comprising said base station including an electronic water control valve wherein said base station is programmed to automatically turns off the main water supply when a leak is detected or alternately can send an alert signal when a leak is detected to ~~a~~ said cell phone, smart phone, mobile phone, or other mobile electronic communication device whereby a user is provided an election to send a command to the base station to control the electronic water control valve to turn off or leave on the main water supply.	
'792 Claim 28 CC5	
28. The water use monitoring apparatus of claim 1, further compromising one or more pressure sensors, said one or more pressure sensors in electrical connection with said first electrical circuity.	Paragraph 0048 - A series of sensors including water temperature sensors 3, water pressure sensors 8, floor moisture sensors 7, vibration flush sensors 5, water meters 2, 4, rain sensors/gauge 16.
'792 Claim 29 CC5	
29. The water use monitoring and leak detection apparatus of claim 1, further compromising one or more temperature sensors, said one or more temperature sensors in electrical connection with said first electrical circuity.	Paragraph 0048 - A series of sensors including water temperature sensors 3, water pressure sensors 8, floor moisture sensors 7, vibration flush sensors 5, water meters 2, 4, rain sensors/gauge 16.
'792 Claim 31 CC5	
31. The water use monitoring and leak detection apparatus of claim 2, further comprising one or more pressure sensors, said one or more pressure sensors in electrical connection with said first electrical circuity.	
'792 Claim 32 CC5	
32. The water use monitoring and leak detection apparatus of claim 2, further comprising one or more temperature sensors, said one or more temperature sensors in electrical connection with said first electrical circuity.	

CC8

US. Patent 9,749,792 Claim Chart - Broniak 9,019,120 in view of Palayur 2011/0035063 and further in view of Ball 8,833,390 and further in view of Vincent 2008/0295895

'792 Claim 1 CC8	
A water parameter use and monitoring apparatus comprising:	'120 Abstract - Methods and systems are disclosed for monitoring water leaks within a home. A home network with various devices monitors these devices with a controller. '063 Abstract - This invention is a water consumption monitoring and control system comprised of a base unit, itself comprising a display and a data entry device, a microprocessor, a communication link to water meters, pressure sensors, temperature sensors, flush toilet vibration sensors and shut-off valves. In addition, the base unit has access to the Internet and can access a server which holds a database of water conservation information, '390 Abstract - A valve meter device, assembly, and method is disclosed including a housing defining at least one inlet opening and at least one outlet opening and a channel connecting the openings, the at least one inlet opening having an inlet end and the at least one outlet opening having an outlet end; a water meter positioned in the channel, the water meter configured to monitor a flow of water through the valve meter device.
A base station apparatus designed to be connected to a main water supply means;	'120 Col. 3, line 36-40 - A main water meter 52 is operatively connected to the main water inlet pipe 50 for measuring a total amount of water flow into the home and communicating information gathered to the controller 10 via a communication module 56. '063 Abstract - This invention is a water consumption monitoring and control system comprised of a base unit, '390 Col. 4, lines 31-33 - As illustrated in FIG. 3, the device housing 110 has an inlet 310 and an outlet 320. Water flows through the device housing 110 by flowing into the inlet 310 and the out of the outlet 320. '895 [0001] This application relates to a water leakage and fault sensing system wherein sensors sense leakage in various locations within a building, and further the water usage is monitored to determine abnormal water usage patterns.
said base station includes a joint means for connecting to a cold/ambient water supply, or a joint means for connecting to a cold/ambient water supply and a joint means for connecting to a hot water supply, said base station have a joint	'120 Col. 3, line 36-40 - A main water meter 52 is operatively connected to the main water inlet pipe 50 for measuring a total amount of water flow into the home.

means for connecting to outgoing water supply line(s) for a home residence, company or building structure;	'390 Col. 4, lines 31-33 - As illustrated in FIG. 3, the device housing 110 has an inlet 310 and an outlet 320. Water flows through the device housing 110 by flowing into the inlet 310 and the out of the outlet 320. '895 [0010] A water monitoring system 20 includes a mains water supply line 24 leading to a building 22.
said apparatus designed to be installed prior to any distribution lines within a residence or commercial building;	'390 Col. 4, lines 46-48 - Water flows into the inlet 310 from a provider or water source and out of the outlet 320 to a home, office building, or other user terminal. '895 [0010] A water monitoring system 20 includes a mains water supply line 24 leading to a building 22.
electrical circuitry including one or more microprocessors or microcontrollers with a power source contained with said base station apparatus;	'120 Col. 2, lines 60-67 - The controller 10 includes a microprocessor, which is programmed to selectively send and/or receive signals to a device control board 24 and 26 of devices 12 and 14, for example, in response to the input signal it receives. '063 . . . paragraph 0054 – … it comprises a microcontroller 21, a display 21, a data entry device 22 and at least one communication link 23. '390 Col. 11, lines 36-42 - Enclosed within the plastic cover 2320a, b is a sealing gasket 2420, a battery 2430, a transceiver 2440, and a printed circuit board (PCB) 2450. Where a "printed circuit board" or PCB is included in the current description, any circuitry which functions as the PCB is intended to be included in alternative embodiments as a variant of a printed circuit board.
said power source is either AC powered, DC powered, or powered with one or more batteries, said power source is electrically connected to said electrical circuitry;	'390 Col. 11, lines 36-42 - Enclosed within the plastic cover 2320a, b is a sealing gasket 2420, a battery 2430, a transceiver 2440, and a printed circuit board (PCB) 2450. Where a "printed circuit board" or PCB is included in the current description, any circuitry which functions as the PCB is intended to be included in alternative embodiments as a variant of a printed circuit board.
one or more flow sensors in communication with a water supply, said one or more flow sensors in electrical communication with said electrical circuitry;	'120 Col.3, lines 52-55 - … includes at least one water meter or flow meter for measuring water that is consumed by a water consuming device and communicating information gathered to the controller 10 via a communication module 56. '063 Paragraph 0048 - A series of sensors including water temperature sensors 3, water pressure sensors 8, floor moisture sensors 7,

	vibration flush sensors 5, water meters 2, 4, rain sensors/gauge 16. ' '390 Col. 11, lines 36-42 - Enclosed within the plastic cover 2320a, b is a sealing gasket 2420, a battery 2430, a transceiver 2440, and a printed circuit board (PCB) 2450. Where a "printed circuit board" or PCB is included in the current description, any circuitry which functions as the PCB is intended to be included in alternative embodiments as a variant of a printed circuit board. 390 Col. 10, lines 38-52 - Internal to the meter is a nutating disc 2110 that interfaces with an output register interaction shaft 2120. The nutating disc 2110 includes a disc pin 2115 which engages the output register interaction shaft 2120. In operation, the nutating disc 2110 and disc pin 2115 wobble about a fixed point in the meter to drive the output register interaction shaft 2120. The output register interaction shaft 2120 is attached to a meter magnet 2130. The meter magnet 2130 has a four-pole arrangement that coordinates with a register 2220 (shown in FIG. 22) such that when the meter magnet 2130 turns the register 2220 logs the motion and provides a readout of water usage. '895 Abstract - Remote sensors are placed at locations that are likely to have leaks occurring. Sensors 34 are preferably placed at locations where a leak might most likely occur. For example, the vicinity of an outside pipe which could break in the winter, the location of a tub, dishwasher, washing machine, etc. would be likely locations for inclusion of a sensor 34. Paragraph 0005 Further, the same system incorporates a flow meter that monitors water usage.
one or more wired or wireless electrical communication means, said or wired wireless electrical communication means having the capability to transfer water parameter, water energy and/or water quality information or data to one or more remote apparatuses, said wired or wireless electrical communication means utilizes protection technology to securely provide water use, water energy and/or water quality information and/or data in a confidential format;	'063, Fig. 1, 2 and 4, Paragraphs 0007, 0008, 0010, 0068-0069 but Broniak fails to disclose water quality sensors or utilize protection technology to securely provide water use, water energy use and/or water quality in a confidential format. '390 Ball monitors water flow fails to disclose water energy use or quality sensors or utilize protection technology to securely provide water use, water energy use and/or water quality in a confidential format. '895 [0012] Remote locations 32 may be provided with remote leakage sensors 34 that are able to communicate through an RF or other wireless connection to the control 28. '895 Vincent fails to disclose water energy use or quality sensors or

	utilize protection technology to securely provide water use, water energy use and/or water quality in a confidential format.
said base station includes mesh-enabled circuitry that can communicate with other base stations for transferring water flow, water energy and/or water quality data;	'390 Col. 11, lines 17-22 - The remotely located communicator may be any communication device or system including a computer, a server, a gateway, another valve meter assembly, a handheld device, a mesh network, or any other device or system capable of communicating with the wireless communication unit 2310.
said base station(s) functioning as one or more access points that transfer said water flow, water energy and/or water quality data, using encryption and identification technology to an internet connection;	'390 Col. 11, lines 7-25 - In an embodiment of the valve meter assembly 1000, the wireless communication unit 2310 may receive signals from the remotely located communicator, or send signals to the remotely located communicator, or both. The wireless communication unit 2310 may include a wireless communication unit circuit 2925 (shown in FIG. 29) as part of the PCB 2450. The wireless communication unit circuit 2925 receives signals from the remotely located communicator. Neither '120, '063, '390 nor '895 disclose any access points nor any encryption or identification technology to an internet connection.
said water flow, water energy and/or water quality data transferred over the internet connection to one or more remote computers or computer servers, and;	'390 Col. 11, lines 17-22 - The remotely located communicator may be any communication device or system including a computer, a server, a gateway, another valve meter assembly, a handheld device, a mesh network, or any other device or system capable of communicating with the wireless communication unit 2310.
said remote computers or servers allow registered owners and users to access their registered water flow, water energy and/or water quality data using a cell phone, smart phone, mobile phone, or a mobile electronic communication device.	Neither '120, '063, '390 nor '895 disclose any means to allow registered owners and users to access their registered water flow, water energy and/or water quality data using a cell phone, smart phone, ~~or~~ mobile phone, or a mobile electronic communication device.
'792 Claim 2 CC8	
a base station in close proximity to a main water supply;	'120 Abstract - Methods and systems are disclosed for monitoring water leaks within a home. A home network with various devices monitors these devices with a controller. '063 Abstract – This invention is a water consumption monitoring and control system comprised of a base unit, itself compromising a display and data entry device, a microprocessor, a communication like to water meters, pressure sensors, temperature sensors and shut off valve. In addition, the base unit has access to the Internet

	and can access a server which holds a database of water conservation information. The database includes watering advisories from local government, and weather information from the weather office. '390 Abstract - A valve meter device, assembly, and method is disclosed including a housing defining at least one inlet opening and at least one outlet opening and a channel connecting the openings, the at least one inlet opening having an inlet end and the at least one outlet opening having an outlet end; a water meter positioned in the channel, the water meter configured to monitor a flow of water through the valve meter device. '895 [0001] This application relates to a water leakage and fault sensing system wherein sensors sense leakage in various locations within a building, and further the water usage is monitored to determine abnormal water usage patterns.
said base station includes a joint means for connecting to a cold/ambient water supply, or a joint means for connecting to a cold/ambient water supply and a joint means for connecting to a hot water supply, said base station have a joint means for connecting to outgoing water supply line(s) for a home residence, company or building structure;	'120 Col. 3, line 36-40 - A main water meter 52 is operatively connected to the main water inlet pipe 50 for measuring a total amount of water flow into the home and communicating information gathered to the controller 10 via a communication module 56. '063 Col. 3, line 36-40 - A main water meter 52 is operatively connected to the main water inlet pipe 50 for measuring a total amount of water flow into the home '390 Col. 4, lines 31-33 - As illustrated in FIG. 3, the device housing 110 has an inlet 310 and an outlet 320. Water flows through the device housing 110 by flowing into the inlet 310 and the out of the outlet 320. '895 [0010] A water monitoring system 20 includes a mains water supply line 24 leading to a building 22.

said base station further comprising a first power supply, said first power supply is either AC powered, DC powered, or powered with one or more batteries, said first power supply electrically connected to a first circuitry which has one or more microprocessors or microcontrollers;	'120 Col. 2, lines 60-67 - The controller 10 includes a microprocessor, which is programmed to selectively send and/or receive signals to a device control board 24 and 26 of devices 12 and 14, for example, in response to the input signal it receives.'063 Col. 2, lines 60-67 - The controller 10 includes a microprocessor, which is programmed to selectively send and/or receive signals to a device control board 24 and 26 of devices 12 and 14, for example, in response to the input signal it receives. '390 Col. 11, lines 36-42 - Enclosed within the plastic cover 2320a, b is a sealing gasket 2420, a battery 2430, a transceiver 2440, and a printed circuit board (PCB) 2450. Where a "printed circuit board" or PCB is included in the current description, any circuitry which functions as the PCB is intended to be included in alternative embodiments as a variant of a printed circuit board.
one or more water flow sensors in communication with a water supply, said one or more water flow sensors in electrical connection with a first electrical circuity;	'120 Col.3, lines 52-55 - … includes at least one water meter or flow meter for measuring water that is consumed by a water consuming device and communicating information gathered to the controller 10 via a communication module 56. '063 Paragraph 0048 - A series of sensors including water temperature sensors 3, water pressure sensors 8, floor moisture sensors 7, vibration flush sensors 5, water meters 2, 4, rain sensors/gauge 16. ' '390 Col. 11, lines 36-42 - Enclosed within the plastic cover 2320a, b is a sealing gasket 2420, a battery 2430, a transceiver 2440, and a printed circuit board (PCB) 2450. Where a "printed circuit board" or PCB is included in the current description, any circuitry which functions as the PCB is intended to be included in alternative embodiments as a variant of a printed circuit board. 390 Col. 10, lines 38-52 - Internal to the meter is a nutating disc 2110 that interfaces with an output register interaction shaft 2120. The nutating disc 2110 includes a disc pin 2115 which engages the output register interaction shaft 2120. In operation, the nutating disc 2110 and disc pin 2115 wobble about a fixed point in the meter to drive the output register interaction shaft 2120. The output register interaction shaft 2120 is attached to a meter magnet 2130. The meter magnet 2130 has a four-pole arrangement that coordinates with a register 2220 (shown in FIG. 22) such that when the meter magnet 2130 turns

	the register 2220 logs the motion and provides a readout of water usage. '895 Abstract - Remote sensors are placed at locations that are likely to have leaks occurring. Sensors 34 are preferably placed at locations where a leak might most likely occur. For example, the vicinity of an outside pipe which could break in the winter, the location of a tub, dishwasher, washing machine, etc. would be likely locations for inclusion of a sensor 34. Paragraph 0005 Further, the same system incorporates a flow meter that monitors water usage.
said base station monitors and processes water parameter data including water flow, water energy, and/or water quality data;	
said base station includes software that controls and sequences the water parameter data and prepares said data for wired or wireless transfer;	'390 Fig. 29, Col. 11, lines 12-22 The communication device in some embodiments may be a wireless communication unit 2310. In the current embodiment, the wireless communication unit 2310 is part of a mesh network where the mesh network includes the remotely located communicator. The remotely located communicator may be operated by a municipality, a technician, a service provider, or another entity. The remotely located communicator may be any communication device or system including a computer, a server, a gateway, another valve meter assembly, a handheld device, a mesh network, or any other device or system capable of communicating with the wireless communication unit 2310.
a receiving station, said receiving station having a second electrical circuitry including one or more second microprocessors, said receiving station remotely located from said base station;	
said receiving station having a second power supply, said second power supply is either AC power, DC power, or powered with one or more batteries, said second power supply electrically connected to a second circuitry;	
said first electrical circuitry of said base station is in wire or wireless communication with said second electrical circuity of said receiving station;	
said receiving station designed to establish Wi-Fi, Bluetooth or ZigBee electrical communication with a wireless router/server, and/or cellular communication with a cell tower technology, and any combinations thereof;	

said receiving station includes mesh-enabled circuitry that can communicate with other receiving stations for transferring water flow, water energy and/or water quality data to one or more access points;	
said receiving station or a custom transfer apparatus functioning as one or more access points for transferring said water flow, water energy and/or water quality data over an internet connection to one or more remote computers or computer servers; and	
said computer servers allow registered owners and users to access their registered water flow, water energy and/or water quality data using a cell phone, smart phone, mobile phone or a mobile electronic communication device.	
'792 Claim 5, CC8	
5. The water use monitoring and leak detection apparatus of claim 1, further comprising said base station including an electronic water control valve wherein said base station is programmed to automatically turns off the main water supply when a leak is detected or alternately can send an alert signal when a leak is detected to ~~a~~ said cell phone, smart phone, mobile phone, or other mobile electronic communication device wherein a user is provided an election to send a command to the base station to control the electronic water control valve to turn off or leave on the main water supply.	'120 Abstract - A shut off valve can be triggered remotely when a request is received from the user, which closes the water pipeline to prevent water damage. Col. 5, lines 10-24 - … the system 8 includes shut off valves 58, 68, and 78 at respective pipelines 50, 60 and 70. The central controller 10 may receive input from the user or homeowner in response to the warning or message, and the user, for example, may respond with instructions to shut off the pipelines 50, 60, and/or 70 via the respective shut off valve 58, 68 and 78 '063 Abstract – This invention is a water consumption monitoring and control system comprised of a base unit, itself compromising a display and data entry device, a microprocessor, a communication like to water meters, pressure sensors, temperature sensors and shut off valve. In addition, the base unit has access to the Internet and can access a server which holds a database of water conservation information. The database includes watering advisories from local government, and weather information from the weather office. '390 Col. 3, lines 46-47 - The valve meter device 100 includes a water supply valve 170 and a water meter 210. Col. 8, lines 3-7 - The solenoid attachment portion 820 is dimensioned to define a solenoid chamber 940 between the solenoid 270

	and the valve cover 120 when the solenoid 270 is attached to the valve cover 120. Col. 16, lines 21- The wireless communication unit circuit 2925 may be configured to log the status of the solenoid 270. For example, the communication unit circuit 2925 may log whether the solenoid 270 is in the closed or open position. '895 [0004] In the disclosed embodiment of this invention, a shut-off valve for a main water supply line to a building is provided with remote signals from leakage sensors. Petitioner contends that the undefined shut-off valve of '120, the water supply valve of '063 the solenoid valve of '390 and the undefined shut-off valve of '895 is not a ball valve design as disclosed and claimed by the present application and thus does not have any capability to perform variable water flow settings.
'792 Claim 7 CC6	
7. The water use monitoring and leak detection apparatus of claim 1, further comprising a water use calibration mode for learning the patterns and signature of water use devices within a home, corporation, building or structure.	
'792 Claim 8 CC6	
8. The water use monitoring and leak detection apparatus of claim 1, further comprising automatic learning mode whereby learning software privately tracks an owner's water flow and volume use for a period, assigning water patterns and water signatures to each specific water use device.	Paragraph 0014 - The inventive control algorithm 28 may be set to "learn" normal usage patterns over the first few months after it has been installed in the building, or it may also be programmed with ranges of normal use for the particular type of building. Deviation from this normal usage by a predetermined amount which would be indicative of a potential leak, and the control would thus shut the valve 26.
'792 Claim 9 CC6	
9. The water use monitoring and leak detection apparatus of claim 2, further comprising a water use calibration mode for learning the patterns and signature of water use devices within a home, corporation, building or structure.	
'792 Claim 10 CC6	

10. The water use monitoring and leak detection apparatus of claim 2, further comprising automatic learning mode whereby learning software privately tracks an owner's water flow and volume use for a period, assigning water patterns and water signatures to each specific water use device.	
'792 Claim 12 CC6	
12. The water use monitoring and leak detection apparatus of claim 1, further comprising a water control means or a variable water flow means, said water control means or variable water flow means ~~is~~ controlled by programming instructions from said microprocessor or microcontroller for turning on and off said water control means or setting a variable water flow means, said water control means or variable water flow means can be activated by an owner's or user's cell phone, smart phones, ~~or~~ mobile phone, or other mobile electronic communication device, or by a remote apparatus or computer or alternately activated by said one or more wireless or wired means controlled by a municipality or governmental agency.	Col. 3, lines 46-47 - The valve meter device 100 includes a water supply valve 170 and a water meter 210. Col. 8, lines 3-7 - The solenoid attachment portion 820 is dimensioned to define a solenoid chamber 940 between the solenoid 270 and the valve cover 120 when the solenoid 270 is attached to the valve cover 120. Petitioner contends that a solenoid valve is not a ball valve design as disclosed and claimed by the present application and thus does not have any capability to perform variable water flow settings. Also see Ball Col. 16, lines … water supply valve 170 is in a dynamic state between open and closed.
'792 Claim 14 CC6	
14. The water use monitoring and leak detection apparatus of claim 2, further comprising a water shut control means or a variable water flow means, said water control means or variable water flow means controlled by programming instructions from said microprocessor or microcontroller for turning on and off said water control means or setting a variable water flow means, said water control means or variable water flow means can be activated by an owner's or user's cell phone, smart phones, mobile phone, or other mobile electronic communication device, or by a remote apparatus or computer or alternately activated by said one or more wireless or wired means controlled by a municipality or governmental agency.	
'792 Claim 17 CC6	
17. The water use monitoring and leak detection apparatus of claim 1, wherein the base station can be incorporated into or serve as the pressure regulator or primary water meter at a residential home or commercial facility.	
'792 Claim 19 CC6	
19. The water use monitoring and leak detection apparatus of claim 2, wherein the base station can	

be incorporated into or serve as the pressure regulator or primary water meter at a residential home or commercial facility.	

'792 Claim 23 CC6	
23. The water use monitoring and leak detection apparatus of claim 2, further comprising said base station including an electronic water control valve wherein said base station is programmed to automatically turns off the main water supply when a leak is detected or alternately can send an alert signal when a leak is detected to ~~a~~ said cell phone, smart phone, mobile phone, or other mobile electronic communication device whereby a user is provided an election to send a command to the base station to control the electronic water control valve to turn off or leave on the main water supply.	
'792 Claim 28 CC6	
28. The water use monitoring apparatus of claim 1, further compromising one or more pressure sensors, said one or more pressure sensors in electrical connection with said first electrical circuity.	Paragraph 0048 - A series of sensors including water temperature sensors 3, water pressure sensors 8, floor moisture sensors 7, vibration flush sensors 5, water meters 2, 4, rain sensors/gauge 16.
'792 Claim 29 CC6	
29. The water use monitoring and leak detection apparatus of claim 1, further compromising one or more temperature sensors, said one or more temperature sensors in electrical connection with said first electrical circuity.	Paragraph 0048 - A series of sensors including water temperature sensors 3, water pressure sensors 8, floor moisture sensors 7, vibration flush sensors 5, water meters 2, 4, rain sensors/gauge 16.
'792 Claim 31 CC6	
31. The water use monitoring and leak detection apparatus of claim 2, further comprising one or more pressure sensors, said one or more pressure sensors in electrical connection with said first electrical circuity.	
'792 Claim 32 CC6	
32. The water use monitoring and leak detection apparatus of claim 2, further comprising one or more temperature sensors, said one or more temperature sensors in electrical connection with said first electrical circuity.	

<u>CC9</u>

US. Patent 9,749,792 Claim Chart - Benson 8,539,827

'792 Claim 1 CC9	
A water use and monitoring and leak detection apparatus comprising:	Abstract - A water meter (10) and a flow control valve (30) are housed in a common pressure vessel (16), in which the flow control valve (30) restricts flow through a metering chamber (18) to less than the normal flow, while still permitting a flow sufficient for basic human needs, rather than completely interrupting supply of the utility, and in which the flow control valve (30) is controlled electrically through a control valve (40) in an energy efficient manner so as to utilize power from a self-contained power source (27) in another device (25) at the customer site (50).
a base station designed to be connected to a main water supply means;	Fig. 1 no. 23 and 24, Col. 2 line 61-64
said base station includes a joint means for connecting to a cold/ambient water supply, or a joint means for connecting to a cold/ambient water supply and a joint means for connecting to a hot water supply, said base station have a joint means for connecting to outgoing water supply line(s) for a home residence, company or building structure;	Fig. 1 no. 23 and 24. Col. 2 lines 61-64. The flow from the inlet 23 to the outlet 24 of the meter housing 11 through the metering chamber 18 is not necessarily a straight path, as the inlet and outlet into the disc metering chamber are often located near each other.
electrical circuitry including one or more microprocessors or microcontrollers with a power source contained with said base station apparatus;	Col. 3, lines 64-67 The hydraulic control circuit is further controlled by a solenoid-controlled hydraulic valve 40 that requires very little electrical energy, and can therefore be powered by a small-capacity battery source.
said power source is either AC powered, DC powered, or powered with one or more batteries, said power source is electrically connected to said electrical circuitry;	Col. 3, lines 64-67 The hydraulic control circuit is further controlled by a solenoid-controlled hydraulic valve 40 that requires very little electrical energy, and can therefore be powered by a small-capacity battery source.
one or more flow sensors in communication with a water supply, said one or more flow sensors in electrical communication with said electrical circuitry;	Col. 2. Lines 47-57 A disc-type water meter 10 includes a meter housing 11 comprising a pressure vessel made from at least one of a low-lead bronze alloy casting, other metals, other metal alloys or plastics. The meter housing 11 includes a tubular inlet conduit 12 leading to a threaded spud end 13, a tubular outlet conduit 14 leading to a threaded spud end 15 and a cylindrical body 16. Inside the cylindrical body, a disc-type meter assembly is disposed and a cover plate (not shown) is bolted to the bottom of the housing 11 to complete the enclosure as is known in the art.

one or more wired or wireless electrical communication means, said or wired wireless electrical communication means having the capability to transfer water parameter, water energy and/or water quality information or data to one or more remote apparatuses, said wired or wireless electrical communication means utilizes protection technology to securely provide water use, water energy and/or water quality information and/or data in a confidential format;	Col. 3, lines 17-30, The radio transceiver 25 includes a radio transmitter portion and a radio receiver portion. The radio transmitter portion converts the utility consumption signals to a radio frequency signaling protocol for transmission back to a network data collector 28 through a wireless network. Although, this embodiment includes an electromechanical type of meter register, it should be understood that the invention can be practiced with electronic types of meter registers that have been more recently developed. As long as some type of electric signal generating meter register 20 is used, it will typically be used with a radio transceiver 25, which is a necessary element in the present embodiments to receive command signals 48 to operate a flow restriction valve 30. **Does not disclose transferring water use data in a confidential format.**
said base station includes mesh-enabled circuitry that can communicate with other base stations for transferring water flow, water energy and/or water quality data;	
said base station(s) functioning as one or more access points that transfer said water flow, water energy and/or water quality data, using encryption and identification technology to an internet connection;	
said water flow, water energy and/or water quality data transferred over the internet connection to one or more remote computers or computer servers, and;	
said remote computers or servers allow registered owners and users to access their registered water flow, water energy and/or water quality data using a cell phone, smart phone, mobile phone, or a mobile electronic communication device.	
'792 Claim 2 CC9	
a base station in close proximity to a main water supply;	Abstract - A water meter (10) and a flow control valve (30) are housed in a common pressure vessel (16), in which the flow control valve (30) restricts flow through a metering chamber (18) to less than the normal flow, while still permitting a flow sufficient for basic human needs, rather than completely interrupting supply of the utility, and in which the flow control valve (30) is controlled electrically through a control valve (40) in an energy efficient manner so as to utilize power from a self-contained power source (27) in another device (25) at the customer site (50).

said base station includes a joint means for connecting to a cold/ambient water supply, or a joint means for connecting to a cold/ambient water supply and a joint means for connecting to a hot water supply, said base station have a joint means for connecting to outgoing water supply line(s) for a home residence, company or building structure;	Fig. 1 no. 23 and 24, Col. 2 line 61-64. The flow from the inlet 23 to the outlet 24 of the meter housing 11 through the metering chamber 18 is not necessarily a straight path, as the inlet and outlet into the disc metering chamber are often located near each other.
said base station further comprising a first power supply, said first power supply is either AC powered, DC powered, or powered with one or more batteries, said first power supply electrically connected to a first circuitry which has one or more microprocessors or microcontrollers;	Col. 3, lines 64-67 The hydraulic control circuit is further controlled by a solenoid-controlled hydraulic valve 40 that requires very little electrical energy, and can therefore be powered by a small-capacity battery source.
one or more water flow sensors in communication with a water supply, said one or more water flow sensors in electrical connection with a first electrical circuity;	Col. 2. Lines 47-57 A disc-type water meter 10 includes a meter housing 11 comprising a pressure vessel made from at least one of a low-lead bronze alloy casting, other metals, other metal alloys or plastics. The meter housing 11 includes a tubular inlet conduit 12 leading to a threaded spud end 13, a tubular outlet conduit 14 leading to a threaded spud end 15 and a cylindrical body 16. Inside the cylindrical body, a disc-type meter assembly is disposed and a cover plate (not shown) is bolted to the bottom of the housing 11 to complete the enclosure as is known in the art.
said base station monitors and processes water parameter data including water flow, water energy, and/or water quality data;	
said base station includes software that controls and sequences the water parameter data and prepares said data for wired or wireless transfer;	
a receiving station, said receiving station having a second electrical circuitry including one or more second microprocessors, said receiving station remotely located from said base station;	
said receiving station having a second power supply, said second power supply is either AC power, DC power, or powered with one or more batteries, said second power supply electrically connected to a second circuitry;	

said first electrical circuitry of said base station is in wire or wireless communication with said second electrical circuity of said receiving station;	
said receiving station designed to establish Wi-Fi, Bluetooth or ZigBee electrical communication with a wireless router/server, and/or cellular communication with a cell tower technology, and any combinations thereof;	
said receiving station includes mesh-enabled circuitry that can communicate with other receiving stations for transferring water flow, water energy and/or water quality data to one or more access points;	
said receiving station or a custom transfer apparatus functioning as one or more access points for transferring said water flow, water energy and/or water quality data over an internet connection to one or more remote computers or computer servers; and	
said computer servers allow registered owners and users to access their registered water flow, water energy and/or water quality data using a cell phone, smart phone, mobile phone or a mobile electronic communication device.	
'792 Claim 5 CC9	
5. The water use monitoring and leak detection apparatus of claim 1, further comprising said base station including an electronic water control valve wherein said base station is programmed to automatically turns off the main water supply when a leak is detected or alternately can send an alert signal when a leak is detected to ~~a~~ said cell phone, smart phone, mobile phone, or other mobile electronic communication device wherein a user is provided an election to send a command to the base station to control the electronic water control valve to turn off or leave on the main water supply.	Col. 1, lines 45-48 This invention houses a water meter and a flow control valve in a common pressure vessel, wherein the flow control valve is a flow restriction valve rather than a complete shut-off valve. Col. 3, lines 35-40 The invention can be practiced with several categories of flow restriction valves including poppet valve, rotating ball valves, diaphragm-actuated valves, and sliding gate valves. In the present invention, a spool valve 30 which is a more complex version of a sliding gate valve is used to restrict flow, rather than to shut-off flow entirely to a customer.

'792 Claim 7 CC9	
7. The water use monitoring and leak detection apparatus of claim 1, further comprising a water use calibration mode for learning the patterns and signature of water use devices within a home, corporation, building or structure.	
'792 Claim 8 CC9	
8. The water use monitoring and leak detection apparatus of claim 1, further comprising automatic learning mode whereby learning software privately tracks an owner's water flow and volume use for a period, assigning water patterns and water signatures to each specific water use device.	
'792 Claim 9 CC9	
9. The water use monitoring and leak detection apparatus of claim 2, further comprising a water use calibration mode for learning the patterns and signature of water use devices within a home, corporation, building or structure.	
'792 Claim 10 CC9	
10. The water use monitoring and leak detection apparatus of claim 2, further comprising automatic learning mode whereby learning software privately tracks an owner's water flow and volume use for a period, assigning water patterns and water signatures to each specific water use device.	
'792 Claim 12 CC9	
12. The water use monitoring and leak detection apparatus of claim 1, further comprising a water control means or a variable water flow means, said water control means or variable water flow means ~~is~~ controlled by programming instructions from said microprocessor or microcontroller for turning on and off said water control means or setting a variable water flow means, said water control means or variable water flow means can be activated by an owner's or user's cell phone, smart phones, ~~or~~ mobile phone, or other mobile electronic communication device, or by a remote apparatus or computer or alternately activated by said one or more wireless or wired means controlled by a municipality or governmental agency.	Col. 1, lines 45-48 This invention houses a water meter and a flow control valve in a common pressure vessel, wherein the flow control valve is a flow restriction valve rather than a complete shut-off valve. Col. 3, lines 35-40 The invention can be practiced with several categories of flow restriction valves including poppet valve, rotating ball valves, diaphragm-actuated valves, and sliding gate valves. In the present invention, a spool valve 30 which is a more complex version of a sliding gate valve is used to restrict flow, rather than to shut-off flow entirely to a customer.

'792 Claim 14 CC9	
14. The water use monitoring and leak detection apparatus of claim 2, further comprising a water shut control means or a variable water flow means, said water control means or variable water flow means controlled by programming instructions from said microprocessor or microcontroller for turning on and off said water control means or setting a variable water flow means, said water control means or variable water flow means can be activated by an owner's or user's cell phone, smart phones, mobile phone, or other mobile electronic communication device, or by a remote apparatus or computer or alternately activated by said one or more wireless or wired means controlled by a municipality or governmental agency.	Col. 1, lines 45-48 This invention houses a water meter and a flow control valve in a common pressure vessel, wherein the flow control valve is a flow restriction valve rather than a complete shut-off valve. Col. 3, lines 35-40 The invention can be practiced with several categories of flow restriction valves including poppet valve, rotating ball valves, diaphragm-actuated valves, and sliding gate valves. In the present invention, a spool valve 30 which is a more complex version of a sliding gate valve is used to restrict flow, rather than to shut-off flow entirely to a customer.
'792 Claim 17 CC9	
17. The water use monitoring and leak detection apparatus of claim 1, wherein the base station can be incorporated into or serve as the pressure regulator or primary water meter at a residential home or commercial facility.	
'792 Claim 19 CC9	
19. The water use monitoring and leak detection apparatus of claim 2, wherein the base station can be incorporated into or serve as the pressure regulator or primary water meter at a residential home or commercial facility.	
'792 Claim 23 CC9	
23. The water use monitoring and leak detection apparatus of claim 2, further comprising said base station including an electronic water control valve wherein said base station is programmed to automatically turns off the main water supply when a leak is detected or alternately can send an alert signal when a leak is detected to ~~a~~ said cell phone, smart phone, mobile phone, or other mobile electronic communication device whereby a user is provided an election to send a command to the base station to control the electronic water control valve to turn off or leave on the main water supply.	Col. 1, lines 45-48 This invention houses a water meter and a flow control valve in a common pressure vessel, wherein the flow control valve is a flow restriction valve rather than a complete shut-off valve. Col. 3, lines 35-40 The invention can be practiced with several categories of flow restriction valves including poppet valve, rotating ball valves, diaphragm-actuated valves, and sliding gate valves. In the present invention, a spool valve 30 which is a more complex version of a sliding gate valve is used to restrict flow, rather than to shut-off flow entirely to a customer.
'792 Claim 28 CC9	
28. The water use monitoring apparatus of claim 1, further compromising one or more pressure sensors, said one or more pressure sensors in electrical connection with said first electrical circuity.	

'792 Claim 29 CC9	
29. The water use monitoring and leak detection apparatus of claim 1, further compromising one or more temperature sensors, said one or more temperature sensors in electrical connection with said first electrical circuity.	
'792 Claim 31 CC9	
31. The water use monitoring and leak detection apparatus of claim 2, further comprising one or more pressure sensors, said one or more pressure sensors in electrical connection with said first electrical circuity.	
'792 Claim 32 CC9	
32. The water use monitoring and leak detection apparatus of claim 2, further comprising one or more temperature sensors, said one or more temperature sensors in electrical connection with said first electrical circuity.	

<u>CC10</u>

US. Patent 9,749,792 Claim Chart - Blackwell 8,644,804

'792 Claim 1 CC10	
A water use and monitoring and leak detection apparatus comprising:	Abstract - A method and a system for collection of meter readings from meter reading and transmitting devices (12, 14) and for viewing on a web-enabled wireless communication device (28) comprises addressing at least one receiver (15) through the Internet (21) and obtaining a data file of meter data for a plurality of meter reading devices (12, 14) that have previously communicated with the receiver (15)...
a base station designed to be connected to a main water supply means;	
said base station includes a joint means for connecting to a cold/ambient water supply, or a joint means for connecting to a cold/ambient water supply and a joint means for connecting to a hot water supply, said base station have a joint means for connecting to outgoing water supply line(s) for a home residence, company or building structure;	
electrical circuitry including one or more microprocessors or microcontrollers with a power source contained with said base station apparatus;	Col. 2 lines 31-33 A plurality of meter reading devices 12 each include a utility meter, a transducer and an RF (radio frequency) transmitter.
said power source is either AC powered, DC powered, or powered with one or more batteries, said power source is electrically connected to said electrical circuitry;	Col. 2 lines 31-33 A plurality of meter reading devices 12 each include a utility meter, a transducer and an RF (radio frequency) transmitter.
one or more flow sensors in communication with a water supply, said one or more flow sensors in electrical communication with said electrical circuitry;	Col. 2 lines 31-33 A plurality of meter reading devices 12 each include a utility meter, a transducer and an RF (radio frequency) transmitter.

one or more wired or wireless electrical communication means, said or wired wireless electrical communication means having the capability to transfer water parameter, water energy and/or water quality information or data to one or more remote apparatuses, said wired or wireless electrical communication means utilizes protection technology to securely provide water use, water energy and/or water quality information and/or data in a confidential format;	Col. 2 lines 51-85 The devices 12, 14 transmit data-encoded RF signals over low power RF frequencies either in the non FCC-licensed ISM (Industrial-Scientific-Medical) band from 902 MHz to 928 MHz or in the FCC-licensed frequencies such as 150-200 Mhz, 325 MHz, 433.92 MHz or from 450 to 470 MHz. **Does not disclose transferring water use data in a confidential format.**
said base station includes mesh-enabled circuitry that can communicate with other base stations for transferring water flow, water energy and/or water quality data;	
said base station(s) functioning as one or more access points that transfer said water flow, water energy and/or water quality data, using encryption and identification technology to an internet connection;	
said water flow, water energy and/or water quality data transferred over the internet connection to one or more remote computers or computer servers, and;	Abstract - A method and a system for collection of meter readings from meter reading and transmitting devices (12, 14) and for viewing on a web-enabled wireless communication device (28) comprises addressing at least one receiver (15) through the Internet (21) and obtaining a data file of meter data for a plurality of meter reading devices (12, 14) that have previously communicated with the receiver (15).
said remote computers or servers allow registered owners and users to access their registered water flow, water energy and/or water quality data using a cell phone, smart phone, ~~or~~ mobile phone, or a mobile electronic communication device.	Abstract - The meter data is then accessed and displayed at a customer demonstration site using a handheld wireless smart phone (28) which receives a web page (22) that is reduced in size for transmission through the cellular network to the smart phone (28). Col. 3, lines 22-28 These web pages can be accessed through a GSM relay network and servers 20 that can convert HTML pages to web pages of a type that can be displayed on the visual display portion of a wireless handheld device, such as a BlackBerry.TM. smart phone, as disclosed in U.S. Pat. No. 7,302,637, issued Nov. 27, 2007, the disclosure of which is incorporated here by reference.

'792 Claim 2 CC10	
a base station in close proximity to a main water supply;	Abstract - A method and a system for collection of meter readings from meter reading and transmitting devices (12, 14) and for viewing on a web-enabled wireless communication device (28) comprises addressing at least one receiver (15) through the Internet (21) and obtaining a data file of meter data for a plurality of meter reading devices (12, 14) that have previously communicated with the receiver (15)…
said base station includes a joint means for connecting to a cold/ambient water supply, or a joint means for connecting to a cold/ambient water supply and a joint means for connecting to a hot water supply, said base station have a joint means for connecting to outgoing water supply line(s) for a home residence, company or building structure;	
said base station further comprising a first power supply, said first power supply is either AC powered, DC powered, or powered with one or more batteries, said first power supply electrically connected to a first circuitry which has one or more microprocessors or microcontrollers;	Col. 2 lines 31-33 A plurality of meter reading devices 12 each include a utility meter, a transducer and an RF (radio frequency) transmitter.
one or more water flow sensors in communication with a water supply, said one or more water flow sensors in electrical connection with a first electrical circuity;	Col. 2 lines 31-33 A plurality of meter reading devices 12 each include a utility meter, a transducer and an RF (radio frequency) transmitter.
said base station monitors and processes water parameter data including water flow, water energy, and/or water quality data;	
said base station includes software that controls and sequences the water parameter data and prepares said data for wired or wireless transfer;	
a receiving station, said receiving station having a second electrical circuitry including one or more second microprocessors, said receiving station remotely located from said base station;	
said receiving station having a second power supply, said second power supply is either AC power, DC power, or powered with one or more batteries, said second power supply electrically connected to a second circuitry;	

said first electrical circuitry of said base station is in wire or wireless communication with said second electrical circuity of said receiving station;	
said receiving station designed to establish Wi-Fi, Bluetooth or ZigBee electrical communication with a wireless router/server, and/or cellular communication with a cell tower technology, and any combinations thereof;	
said receiving station includes mesh-enabled circuitry that can communicate with other receiving stations for transferring water flow, water energy and/or water quality data to one or more access points;	
said receiving station or a custom transfer apparatus functioning as one or more access points for transferring said water flow, water energy and/or water quality data over an internet connection to one or more remote computers or computer servers; and	Abstract - A method and a system for collection of meter readings from meter reading and transmitting devices (12, 14) and for viewing on a web-enabled wireless communication device (28) comprises addressing at least one receiver (15) through the Internet (21) and obtaining a data file of meter data for a plurality of meter reading devices (12, 14) that have previously communicated with the receiver (15).
said computer servers allow registered owners and users to access their registered water flow, water energy and/or water quality data using a cell phone, smart phone, mobile phone or a mobile electronic communication device.	Abstract - The meter data is then accessed and displayed at a customer demonstration site using a handheld wireless smart phone (28) which receives a web page (22) that is reduced in size for transmission through the cellular network to the smart phone (28). Col. 3, lines 22-28 These web pages can be accessed through a GSM relay network and servers 20 that can convert HTML pages to web pages of a type that can be displayed on the visual display portion of a wireless handheld device, such as a BlackBerry.TM. smart phone, as disclosed in U.S. Pat. No. 7,302,637, issued Nov. 27, 2007, the disclosure of which is incorporated here by reference.

'792 Claim 5 CC10	
5. The water use monitoring and leak detection apparatus of claim 1, further comprising said base station including an electronic water control valve wherein said base station is programmed to automatically turns off the main water supply when a leak is detected or alternately can send an alert signal when a leak is detected to ~~a~~ said cell phone, smart phone, mobile phone, or other mobile electronic communication device wherein a user is provided an election to send a command to the base station to control the electronic water control valve to turn off or leave on the main water supply.	
'792 Claim 7 CC10	
7. The water use monitoring and leak detection apparatus of claim 1, further comprising a water use calibration mode for learning the patterns and signature of water use devices within a home, corporation, building or structure.	
'792 Claim 8 CC10	
8. The water use monitoring and leak detection apparatus of claim 1, further comprising automatic learning mode whereby learning software privately tracks an owner's water flow and volume use for a period, assigning water patterns and water signatures to each specific water use device.	
'792 Claim 9 CC10	
9. The water use monitoring and leak detection apparatus of claim 2, further comprising a water use calibration mode for learning the patterns and signature of water use devices within a home, corporation, building or structure.	
'792 Claim 10 CC10	
10. The water use monitoring and leak detection apparatus of claim 2, further comprising automatic learning mode whereby learning software privately tracks an owner's water flow and volume use for a period, assigning water patterns and water signatures to each specific water use device.	

'792 Claim 12 CC10	
12. The water use monitoring and leak detection apparatus of claim 1, further comprising a water control means or a variable water flow means, said water control means or variable water flow means ~~is~~ controlled by programming instructions from said microprocessor or microcontroller for turning on and off said water control means or setting a variable water flow means, said water control means or variable water flow means can be activated by an owner's or user's cell phone, smart phones, ~~or~~ mobile phone, or other mobile electronic communication device, or by a remote apparatus or computer or alternately activated by said one or more wireless or wired means controlled by a municipality or governmental agency.	
'792 Claim 14 CC10	
14. The water use monitoring and leak detection apparatus of claim 2, further comprising a water shut control means or a variable water flow means, said water control means or variable water flow means controlled by programming instructions from said microprocessor or microcontroller for turning on and off said water control means or setting a variable water flow means, said water control means or variable water flow means can be activated by an owner's or user's cell phone, smart phones, mobile phone, or other mobile electronic communication device, or by a remote apparatus or computer or alternately activated by said one or more wireless or wired means controlled by a municipality or governmental agency.	
'792 Claim 17 CC10	
17. The water use monitoring and leak detection apparatus of claim 1, wherein the base station can be incorporated into or serve as the pressure regulator or primary water meter at a residential home or commercial facility.	
'792 Claim 19 CC10	
19. The water use monitoring and leak detection apparatus of claim 2, wherein the base station can be incorporated into or serve as the pressure regulator or primary water meter at a residential home or commercial facility.	

'792 Claim 23 CC10	
23. The water use monitoring and leak detection apparatus of claim 2, further comprising said base station including an electronic water control valve wherein said base station is programmed to automatically turns off the main water supply when a leak is detected or alternately can send an alert signal when a leak is detected to ~~a~~ said cell phone, smart phone, mobile phone, or other mobile electronic communication device whereby a user is provided an election to send a command to the base station to control the electronic water control valve to turn off or leave on the main water supply.	
'792 Claim 28 CC10	
28. The water use monitoring apparatus of claim 1, further compromising one or more pressure sensors, said one or more pressure sensors in electrical connection with said first electrical circuity.	
'792 Claim 29 CC10	
29. The water use monitoring and leak detection apparatus of claim 1, further compromising one or more temperature sensors, said one or more temperature sensors in electrical connection with said first electrical circuity.	
'792 Claim 31 CC10	
31. The water use monitoring and leak detection apparatus of claim 2, further comprising one or more pressure sensors, said one or more pressure sensors in electrical connection with said first electrical circuity.	
'792 Claim 32 CC10	
32. The water use monitoring and leak detection apparatus of claim 2, further comprising one or more temperature sensors, said one or more temperature sensors in electrical connection with said first electrical circuity.	

<u>CC6</u>

US. Patent 9,749,792 Claim Chart - Broniak 9,019,120 in view of Palayur 2011/0035063 and further in view of Ball 8,833,390 and further in view of Petite 8,013,732

'792 Claim 1 CC6	
A water parameter use and monitoring apparatus comprising:	'120 Abstract - Methods and systems are disclosed for monitoring water leaks within a home. A home network with various devices monitors these devices with a controller. '063 Abstract - This invention is a water consumption monitoring and control system comprised of a base unit, itself comprising a display and a data entry device, a microprocessor, a communication link to water meters, pressure sensors, temperature sensors, flush toilet vibration sensors and shut-off valves. In addition, the base unit has access to the Internet and can access a server which holds a database of water conservation information, '390 Abstract - A valve meter device, assembly, and method is disclosed including a housing defining at least one inlet opening and at least one outlet opening and a channel connecting the openings, the at least one inlet opening having an inlet end and the at least one outlet opening having an outlet end; a water meter positioned in the channel, the water meter configured to monitor a flow of water through the valve meter device.
A base station apparatus designed to be connected to a main water supply means;	'120 Col. 3, line 36-40 - A main water meter 52 is operatively connected to the main water inlet pipe 50 for measuring a total amount of water flow into the home and communicating information gathered to the controller 10 via a communication module 56. '063 Abstract - This invention is a water consumption monitoring and control system comprised of a base unit, '390 Col. 4, lines 31-33 - As illustrated in FIG. 3, the device housing 110 has an inlet 310 and an outlet 320. Water flows through the device housing 110 by flowing into the inlet 310 and the out of the outlet 320.
said base station includes a joint means for connecting to a cold/ambient water supply, or a joint means for connecting to a cold/ambient water supply and a joint means for connecting to a hot water supply, said base station have a joint means for connecting to outgoing water supply line(s) for a home residence, company or building structure;	'120 Col. 3, line 36-40 - A main water meter 52 is operatively connected to the main water inlet pipe 50 for measuring a total amount of water flow into the home, '390 Col. 4, lines 31-33 - As illustrated in FIG. 3, the device housing 110 has an inlet 310 and an outlet 320. Water flows through the device housing 110 by flowing into the inlet 310 and the out of the outlet 320.

said apparatus designed to be installed prior to any distribution lines within a residence or commercial building;	'390 Col. 4, lines 46-48 - Water flows into the inlet 310 from a provider or water source and out of the outlet 320 to a home, office building, or other user terminal.
electrical circuitry including one or more microprocessors or microcontrollers with a power source contained with said base station apparatus;	'120 Col. 2, lines 60-67 - The controller 10 includes a microprocessor, which is programmed to selectively send and/or receive signals to a device control board 24 and 26 of devices 12 and 14, for example, in response to the input signal it receives. '063 . . . paragraph 0054 – … it comprises a microcontroller 21, a display 21, a data entry device 22 and at least one communication link 23. '390 Col. 11, lines 36-42 - Enclosed within the plastic cover 2320a, b is a sealing gasket 2420, a battery 2430, a transceiver 2440, and a printed circuit board (PCB) 2450. Where a "printed circuit board" or PCB is included in the current description, any circuitry which functions as the PCB is intended to be included in alternative embodiments as a variant of a printed circuit board.
said power source is either AC powered, DC powered, or powered with one or more batteries, said power source is electrically connected to said electrical circuitry;	'390 Col. 11, lines 36-42 - Enclosed within the plastic cover 2320a, b is a sealing gasket 2420, a battery 2430, a transceiver 2440, and a printed circuit board (PCB) 2450. Where a "printed circuit board" or PCB is included in the current description, any circuitry which functions as the PCB is intended to be included in alternative embodiments as a variant of a printed circuit board.
one or more flow sensors in communication with a water supply, said one or more flow sensors in electrical communication with said electrical circuitry;	'120 Col.3, lines 52-55 - … includes at least one water meter or flow meter for measuring water that is consumed by a water consuming device and communicating information gathered to the controller 10 via a communication module 56. '063 Paragraph 0048 - A series of sensors including water temperature sensors 3, water pressure sensors 8, floor moisture sensors 7, vibration flush sensors 5, water meters 2, 4, rain sensors/gauge 16. ' '390 Col. 11, lines 36-42 - Enclosed within the plastic cover 2320a, b is a sealing gasket 2420, a battery 2430, a transceiver 2440, and a printed circuit board (PCB) 2450. Where a "printed circuit board" or PCB is included in the current description, any circuitry which functions as the PCB is intended to be included in alternative embodiments as a variant of a printed circuit board. 390 Col. 10, lines 38-52 - Internal to the meter is a nutating disc 2110 that interfaces with

	an output register interaction shaft 2120. The nutating disc 2110 includes a disc pin 2115 which engages the output register interaction shaft 2120. In operation, the nutating disc 2110 and disc pin 2115 wobble about a fixed point in the meter to drive the output register interaction shaft 2120. The output register interaction shaft 2120 is attached to a meter magnet 2130. The meter magnet 2130 has a four-pole arrangement that coordinates with a register 2220 (shown in FIG. 22) such that when the meter magnet 2130 turns the register 2220 logs the motion and provides a readout of water usage.
one or more wired or wireless electrical communication means, said or wired wireless electrical communication means having the capability to transfer water parameter, water energy and/or water quality information or data to one or more remote apparatuses, said wired or wireless electrical communication means utilizes protection technology to securely provide water use, water energy and/or water quality information and/or data in a confidential format;	'063, Fig. 1, 2 and 4, Paragraphs 0007, 0008, 0010, 0068-0069 but Broniak fails to disclose water quality sensors or utilize protection technology to securely provide water use, water energy use and/or water quality in a confidential format. '390 Ball monitors water flow fails to disclose water energy use or quality sensors or utilize protection technology to securely provide water use, water energy use and/or water quality in a confidential format. '732 Fig. 3a, 3b, 4, 5, 6, 8 Col. 13, lines 17-39 but Petite fails to disclose water quality sensors or utilize protection technology to securely provide water use, water energy use and/or water quality in a confidential format.
said base station includes mesh-enabled circuitry that can communicate with other base stations for transferring water flow, water energy and/or water quality data;	'390 Col. 11, lines 17-22 - The remotely located communicator may be any communication device or system including a computer, a server, a gateway, another valve meter assembly, a handheld device, a mesh network, or any other device or system capable of communicating with the wireless communication unit 2310.
said base station(s) functioning as one or more access points that transfer said water flow, water energy and/or water quality data, using encryption and identification technology to an internet connection;	'390 Col. 11, lines 7-25 - In an embodiment of the valve meter assembly 1000, the wireless communication unit 2310 may receive signals from the remotely located communicator, or send signals to the remotely located communicator, or both. The wireless communication unit 2310 may include a wireless communication unit circuit 2925 (shown in FIG. 29) as part of the PCB 2450. The wireless communication unit circuit 2925 receives signals from the remotely located communicator. Neither '120, '063, or '390 disclose any access points nor any encryption or identification technology to an internet connection.

said water flow, water energy and/or water quality data transferred over the internet connection to one or more remote computers or computer servers, and;	'390 Col. 11, lines 17-22 - The remotely located communicator may be any communication device or system including a computer, a server, a gateway, another valve meter assembly, a handheld device, a mesh network, or any other device or system capable of communicating with the wireless communication unit 2310. '732 Fig. 3a, 3b, 4, 5, 6, 8 Col. 13, lines 17-39
said remote computers or servers allow registered owners and users to access their registered water flow, water energy and/or water quality data using a cell phone, smart phone, mobile phone, or a mobile electronic communication device.	Neither '120, '063, or '390 disclose any means to allow registered owners and users to access their registered water flow, water energy and/or water quality data using a cell phone, smart phone, ~~or~~ mobile phone, or a mobile electronic communication device.
'792 Claim 2 CC6	
a base station in close proximity to a main water supply;	'120 Abstract - Methods and systems are disclosed for monitoring water leaks within a home. A home network with various devices monitors these devices with a controller. '063 Abstract – This invention is a water consumption monitoring and control system comprised of a base unit, itself compromising a display and data entry device, a microprocessor, a communication like to water meters, pressure sensors, temperature sensors and shut off valve. In addition, the base unit has access to the Internet and can access a server which holds a database of water conservation information. The database includes watering advisories from local government, and weather information from the weather office. '390 Abstract - A valve meter device, assembly, and method is disclosed including a housing defining at least one inlet opening and at least one outlet opening and a channel connecting the openings, the at least one inlet opening having an inlet end and the at least one outlet opening having an outlet end; a water meter positioned in the channel, the water meter configured to monitor a flow of water through the valve meter device.
said base station includes a joint means for connecting to a cold/ambient water supply, or a joint means for connecting to a cold/ambient water supply and a joint means for connecting to a hot water supply, said base station have a joint means for connecting to outgoing water supply line(s) for a home residence, company or building structure;	'120 Col. 3, line 36-40 - A main water meter 52 is operatively connected to the main water inlet pipe 50 for measuring a total amount of water flow into the home and communicating information gathered to the controller 10 via a communication module 56. '063 Col. 3, line 36-40 - A main water meter 52 is operatively connected to the main water inlet pipe 50 for measuring a total amount of water flow into the home

	'390 Col. 4, lines 31-33 - As illustrated in FIG. 3, the device housing 110 has an inlet 310 and an outlet 320. Water flows through the device housing 110 by flowing into the inlet 310 and the out of the outlet 320.
said base station further comprising a first power supply, said first power supply is either AC powered, DC powered, or powered with one or more batteries, said first power supply electrically connected to a first circuitry which has one or more microprocessors or microcontrollers;	'120 Col. 2, lines 60-67 - The controller 10 includes a microprocessor, which is programmed to selectively send and/or receive signals to a device control board 24 and 26 of devices 12 and 14, for example, in response to the input signal it receives. '063 Col. 2, lines 60-67 - The controller 10 includes a microprocessor, which is programmed to selectively send and/or receive signals to a device control board 24 and 26 of devices 12 and 14, for example, in response to the input signal it receives. '390 Col. 11, lines 36-42 - Enclosed within the plastic cover 2320a, b is a sealing gasket 2420, a battery 2430, a transceiver 2440, and a printed circuit board (PCB) 2450. Where a "printed circuit board" or PCB is included in the current description, any circuitry which functions as the PCB is intended to be included in alternative embodiments as a variant of a printed circuit board.
one or more water flow sensors in communication with a water supply, said one or more water flow sensors in electrical connection with a first electrical circuitry;	'120 Col.3, lines 52-55 - … includes at least one water meter or flow meter for measuring water that is consumed by a water consuming device and communicating information gathered to the controller 10 via a communication module 56. '063 Paragraph 0048 - A series of sensors including water temperature sensors 3, water pressure sensors 8, floor moisture sensors 7, vibration flush sensors 5, water meters 2, 4, rain sensors/gauge 16. ' '390 Col. 11, lines 36-42 - Enclosed within the plastic cover 2320a, b is a sealing gasket 2420, a battery 2430, a transceiver 2440, and a printed circuit board (PCB) 2450. Where a "printed circuit board" or PCB is included in the current description, any circuitry which functions as the PCB is intended to be included in alternative embodiments as a variant of a printed circuit board. 390 Col. 10, lines 38-52 - Internal to the meter is a nutating disc 2110 that interfaces with an output register interaction shaft 2120. The nutating disc 2110 includes a disc pin 2115 which engages the output register interaction shaft 2120. In operation, the nutating disc 2110 and disc pin 2115 wobble about a fixed point in the meter to

	drive the output register interaction shaft 2120. The output register interaction shaft 2120 is attached to a meter magnet 2130. The meter magnet 2130 has a four-pole arrangement that coordinates with a register 2220 (shown in FIG. 22) such that when the meter magnet 2130 turns the register 2220 logs the motion and provides a readout of water usage.
said base station monitors and processes water parameter data including water flow, water energy, and/or water quality data;	
said base station includes software that controls and sequences the water parameter data and prepares said data for wired or wireless transfer;	'390 Fig. 29, Col. 11, lines 12-22 The communication device in some embodiments may be a wireless communication unit 2310. In the current embodiment, the wireless communication unit 2310 is part of a mesh network where the mesh network includes the remotely located communicator. The remotely located communicator may be operated by a municipality, a technician, a service provider, or another entity. The remotely located communicator may be any communication device or system including a computer, a server, a gateway, another valve meter assembly, a handheld device, a mesh network, or any other device or system capable of communicating with the wireless communication unit 2310.
a receiving station, said receiving station having a second electrical circuitry including one or more second microprocessors, said receiving station remotely located from said base station;	
said receiving station having a second power supply, said second power supply is either AC power, DC power, or powered with one or more batteries, said second power supply electrically connected to a second circuitry;	
said first electrical circuitry of said base station is in wire or wireless communication with said second electrical circuity of said receiving station;	
said receiving station designed to establish Wi-Fi, Bluetooth or ZigBee electrical communication with a wireless router/server, and/or cellular communication with a cell tower technology, and any combinations thereof;	

said receiving station includes mesh-enabled circuitry that can communicate with other receiving stations for transferring water flow, water energy and/or water quality data to one or more access points;	
said receiving station or a custom transfer apparatus functioning as one or more access points for transferring said water flow, water energy and/or water quality data over an internet connection to one or more remote computers or computer servers; and	
said computer servers allow registered owners and users to access their registered water flow, water energy and/or water quality data using a cell phone, smart phone, mobile phone or a mobile electronic communication device.	
'792 Claim 5, CC6	
5. The water use monitoring and leak detection apparatus of claim 1, further comprising said base station including an electronic water control valve wherein said base station is programmed to automatically turns off the main water supply when a leak is detected or alternately can send an alert signal when a leak is detected to ~~a~~ said cell phone, smart phone, mobile phone, or other mobile electronic communication device wherein a user is provided an election to send a command to the base station to control the electronic water control valve to turn off or leave on the main water supply.	'120 Abstract - A shut off valve can be triggered remotely when a request is received from the user, which closes the water pipeline to prevent water damage. Col. 5, lines 10-24 - … the system 8 includes shut off valves 58, 68, and 78 at respective pipelines 50, 60 and 70. The central controller 10 may receive input from the user or homeowner in response to the warning or message, and the user, for example, may respond with instructions to shut off the pipelines 50, 60, and/or 70 via the respective shut off valve 58, 68 and 78 '063 Abstract – This invention is a water consumption monitoring and control system comprised of a base unit, itself compromising a display and data entry device, a microprocessor, a communication like to water meters, pressure sensors, temperature sensors and shut off valve. In addition, the base unit has access to the Internet and can access a server which holds a database of water conservation information. The database includes watering advisories from local government, and weather information from the weather office. '390 Col. 3, lines 46-47 - The valve meter device 100 includes a water supply valve 170 and a water meter 210. Col. 8, lines 3-7 - The solenoid attachment portion 820 is dimensioned to define a solenoid chamber 940 between the solenoid 270 and the valve cover 120 when the solenoid 270 is

	attached to the valve cover 120. Col. 16, lines 21- The wireless communication unit circuit 2925 may be configured to log the status of the solenoid 270. For example, the communication unit circuit 2925 may log whether the solenoid 270 is in the closed or open position. Petitioner contends that a solenoid valve is not a ball valve design as disclosed and claimed by the present application and thus does not have any capability to perform variable water flow settings.
'792 Claim 7 CC6	
7. The water use monitoring and leak detection apparatus of claim 1, further comprising a water use calibration mode for learning the patterns and signature of water use devices within a home, corporation, building or structure.	
'792 Claim 8 CC6	
8. The water use monitoring and leak detection apparatus of claim 1, further comprising automatic learning mode whereby learning software privately tracks an owner's water flow and volume use for a period, assigning water patterns and water signatures to each specific water use device.	
'792 Claim 9 CC6	
9. The water use monitoring and leak detection apparatus of claim 2, further comprising a water use calibration mode for learning the patterns and signature of water use devices within a home, corporation, building or structure.	
'792 Claim 10 CC6	
10. The water use monitoring and leak detection apparatus of claim 2, further comprising automatic learning mode whereby learning software privately tracks an owner's water flow and volume use for a period, assigning water patterns and water signatures to each specific water use device.	
'792 Claim 12 CC6	
12. The water use monitoring and leak detection apparatus of claim 1, further comprising a water control means or a variable water flow means, said water control means or variable water flow means ~~is~~ controlled by programming instructions	Col. 3, lines 46-47 - The valve meter device 100 includes a water supply valve 170 and a water meter 210. Col. 8, lines 3-7 - The solenoid attachment portion 820 is dimensioned to define a solenoid chamber 940 between the solenoid 270

from said microprocessor or microcontroller for turning on and off said water control means or setting a variable water flow means, said water control means or variable water flow means can be activated by an owner's or user's cell phone, smart phones, ~~or~~ mobile phone, or other mobile electronic communication device, or by a remote apparatus or computer or alternately activated by said one or more wireless or wired means controlled by a municipality or governmental agency.	and the valve cover 120 when the solenoid 270 is attached to the valve cover 120. Petitioner contends that a solenoid valve is not a ball valve design as disclosed and claimed by the present application and thus does not have any capability to perform variable water flow settings. Also see Ball Col. 16, lines … water supply valve 170 is in a dynamic state between open and closed.
'792 Claim 14 CC6	
14. The water use monitoring and leak detection apparatus of claim 2, further comprising a water shut control means or a variable water flow means, said water control means or variable water flow means controlled by programming instructions from said microprocessor or microcontroller for turning on and off said water control means or setting a variable water flow means, said water control means or variable water flow means can be activated by an owner's or user's cell phone, smart phones, mobile phone, or other mobile electronic communication device, or by a remote apparatus or computer or alternately activated by said one or more wireless or wired means controlled by a municipality or governmental agency.	
'792 Claim 17 CC6	
17. The water use monitoring and leak detection apparatus of claim 1, wherein the base station can be incorporated into or serve as the pressure regulator or primary water meter at a residential home or commercial facility.	
'792 Claim 19 CC6	
19. The water use monitoring and leak detection apparatus of claim 2, wherein the base station can be incorporated into or serve as the pressure regulator or primary water meter at a residential home or commercial facility.	

'792 Claim 23 CC6	
23. The water use monitoring and leak detection apparatus of claim 2, further comprising said base station including an electronic water control valve wherein said base station is programmed to automatically turns off the main water supply when a leak is detected or alternately can send an alert signal when a leak is detected to ~~a~~ said cell phone, smart phone, mobile phone, or other mobile electronic communication device whereby a user is provided an election to send a command to the base station to control the electronic water control valve to turn off or leave on the main water supply.	
'792 Claim 28 CC6	
28. The water use monitoring apparatus of claim 1, further compromising one or more pressure sensors, said one or more pressure sensors in electrical connection with said first electrical circuity.	Paragraph 0048 - A series of sensors including water temperature sensors 3, water pressure sensors 8, floor moisture sensors 7, vibration flush sensors 5, water meters 2, 4, rain sensors/gauge 16.
'792 Claim 29 CC6	
29. The water use monitoring and leak detection apparatus of claim 1, further compromising one or more temperature sensors, said one or more temperature sensors in electrical connection with said first electrical circuity.	Paragraph 0048 - A series of sensors including water temperature sensors 3, water pressure sensors 8, floor moisture sensors 7, vibration flush sensors 5, water meters 2, 4, rain sensors/gauge 16.
'792 Claim 31 CC6	
31. The water use monitoring and leak detection apparatus of claim 2, further comprising one or more pressure sensors, said one or more pressure sensors in electrical connection with said first electrical circuity.	
'792 Claim 32 CC6	
32. The water use monitoring and leak detection apparatus of claim 2, further comprising one or more temperature sensors, said one or more temperature sensors in electrical connection with said first electrical circuity.	

CC7

US. Patent 9,749,792 Claim Chart - Broniak 9,019,120 in view of Palayur 2011/0035063 and further in view of Ball 8,833,390 and further in view of Casie 6,105,607

'792 Claim 1 CC7	
A water parameter use and monitoring apparatus comprising:	'120 Abstract - Methods and systems are disclosed for monitoring water leaks within a home. A home network with various devices monitors these devices with a controller. '063 Abstract - This invention is a water consumption monitoring and control system comprised of a base unit, itself comprising a display and a data entry device, a microprocessor, a communication link to water meters, pressure sensors, temperature sensors, flush toilet vibration sensors and shut-off valves. In addition, the base unit has access to the Internet and can access a server which holds a database of water conservation information, '390 Abstract - A valve meter device, assembly, and method is disclosed including a housing defining at least one inlet opening and at least one outlet opening and a channel connecting the openings, the at least one inlet opening having an inlet end and the at least one outlet opening having an outlet end; a water meter positioned in the channel, the water meter configured to monitor a flow of water through the valve meter device. '607 Abstract – a microprocessor based control system to monitor flow in a portable water system and with pre-set programs of time of day and duration of flow, if the preset parameters are exceeded the controller will turn off the flow of water.
A base station apparatus designed to be connected to a main water supply means;	'120 Col. 3, line 36-40 - A main water meter 52 is operatively connected to the main water inlet pipe 50 for measuring a total amount of water flow into the home and communicating information gathered to the controller 10 via a communication module 56. '063 Abstract - This invention is a water consumption monitoring and control system comprised of a base unit, '390 Col. 4, lines 31-33 - As illustrated in FIG. 3, the device housing 110 has an inlet 310 and an outlet 320. Water flows through the device housing 110 by flowing into the inlet 310 and the out of the outlet 320.

said base station includes a joint means for connecting to a cold/ambient water supply, or a joint means for connecting to a cold/ambient water supply and a joint means for connecting to a hot water supply, said base station have a joint means for connecting to outgoing water supply line(s) for a home residence, company or building structure;	'120 Col. 3, line 36-40 - A main water meter 52 is operatively connected to the main water inlet pipe 50 for measuring a total amount of water flow into the home, '390 Col. 4, lines 31-33 - As illustrated in FIG. 3, the device housing 110 has an inlet 310 and an outlet 320. Water flows through the device housing 110 by flowing into the inlet 310 and the out of the outlet 320. '607 Col. 3, lines 31-33 - Referring to FIGS. 1, 2 and 5 of the drawings, a fluid flow detection and shut-off system of the invention can be seen for use in residential of commercial structures.
said apparatus designed to be installed prior to any distribution lines within a residence or commercial building;	'390 Col. 4, lines 46-48 - Water flows into the inlet 310 from a provider or water source and out of the outlet 320 to a home, office building, or other user terminal.
electrical circuitry including one or more microprocessors or microcontrollers with a power source contained with said base station apparatus;	'120 Col. 2, lines 60-67 - The controller 10 includes a microprocessor, which is programmed to selectively send and/or receive signals to a device control board 24 and 26 of devices 12 and 14, for example, in response to the input signal it receives. '063 . . . paragraph 0054 -- … it comprises a microcontroller 21, a display 21, a data entry device 22 and at least one communication link 23. '390 Col. 11, lines 36-42 - Enclosed within the plastic cover 2320a, b is a sealing gasket 2420, a battery 2430, a transceiver 2440, and a printed circuit board (PCB) 2450. Where a "printed circuit board" or PCB is included in the current description, any circuitry which functions as the PCB is intended to be included in alternative embodiments as a variant of a printed circuit board. '607 Col. 3, lines 35-40 The shut-off system of the invention has a main control unit 10 with power supplied by a step down transformer 11 from a live power source of 110 volt AC to a transformer output at 13 of 12 volts DC which supplies the main controller 10 of the system
said power source is either AC powered, DC powered, or powered with one or more batteries, said power source is electrically connected to said electrical circuitry;	'390 Col. 11, lines 36-42 - Enclosed within the plastic cover 2320a, b is a sealing gasket 2420, a battery 2430, a transceiver 2440, and a printed circuit board (PCB) 2450. Where a "printed circuit board" or PCB is included in the current description, any circuitry which functions as the PCB is intended to be included in alternative embodiments as a variant of a printed circuit board.

	'607 Col. 3, lines 35-40 The shut-off system of the invention has a main control unit 10 with power supplied by a step down transformer 11 from a live power source of 110 volt AC to a transformer output at 13 of 12 volts DC which supplies the main controller 10 of the system
one or more flow sensors in communication with a water supply, said one or more flow sensors in electrical communication with said electrical circuitry;	'120 Col.3, lines 52-55 - … includes at least one water meter or flow meter for measuring water that is consumed by a water consuming device and communicating information gathered to the controller 10 via a communication module 56. '063 Paragraph 0048 - A series of sensors including water temperature sensors 3, water pressure sensors 8, floor moisture sensors 7, vibration flush sensors 5, water meters 2, 4, rain sensors/gauge 16. ' 390 Col. 11, lines 36-42 - Enclosed within the plastic cover 2320a, b is a sealing gasket 2420, a battery 2430, a transceiver 2440, and a printed circuit board (PCB) 2450. Where a "printed circuit board" or PCB is included in the current description, any circuitry which functions as the PCB is intended to be included in alternative embodiments as a variant of a printed circuit board. 390 Col. 10, lines 38-52 - Internal to the meter is a nutating disc 2110 that interfaces with an output register interaction shaft 2120. The nutating disc 2110 includes a disc pin 2115 which engages the output register interaction shaft 2120. In operation, the nutating disc 2110 and disc pin 2115 wobble about a fixed point in the meter to drive the output register interaction shaft 2120. The output register interaction shaft 2120 is attached to a meter magnet 2130. The meter magnet 2130 has a four-pole arrangement that coordinates with a register 2220 (shown in FIG. 22) such that when the meter magnet 2130 turns the register 2220 logs the motion and provides a readout of water usage. '607 Col. 4, lines 10-24 - Referring now to FIG. 3 of the drawings, the flow sensor 18 can be seen having a valve body 30 with an inlet opening 31 and an oppositely disposed outlet opening 32. A valve seat 33 is formed between the inlet and outlet openings with a ball valve element 34 movable within valve guides 35. A leaf type spring 36 extends from the control head 43 and is engageable against the valve ball element 34 urging same into the valve seat 33. A backpressure port 37 upstream of the valve ball element 34 communicates with a chamber 38 having a

	magnetized piston 39 and a calibrated spring 40. A back pressure outlet port 41 communicates with the chamber 38 allowing for movement of the magnetized piston 39 against the spring 40 when flow occurs indicated by the arrows in broken lines and the ball element position at 34A. The flow sensor disclosed in Fig 3 and column 4, lines 10-39 is non-typical custom design and it is not clear to one skill in the art that this custom design can accurately monitor the actual water flow rate. It may be a binary flow sensor design only monitoring flow or no flow.
one or more wired or wireless electrical communication means, said or wired wireless electrical communication means having the capability to transfer water parameter, water energy and/or water quality information or data to one or more remote apparatuses, said wired or wireless electrical communication means utilizes protection technology to securely provide water use, water energy and/or water quality information and/or data in a confidential format;	'063, Fig. 1, 2 and 4, Paragraphs 0007, 0008, 0010, 0068-0069 but Broniak fails to disclose water quality sensors or utilize protection technology to securely provide water use, water energy use and/or water quality in a confidential format. '390 Ball monitors water flow fails to disclose water energy use or quality sensors or utilize protection technology to securely provide water use, water energy use and/or water quality in a confidential format. '607 Caise flow meter can on detect if flow is on or off, and the is not disclosure of using actual water flow from flow (rate) sensors.
said base station includes mesh-enabled circuitry that can communicate with other base stations for transferring water flow, water energy and/or water quality data;	'390 Col. 11, lines 17-22 - The remotely located communicator may be any communication device or system including a computer, a server, a gateway, another valve meter assembly, a handheld device, a mesh network, or any other device or system capable of communicating with the wireless communication unit 2310.
said base station(s) functioning as one or more access points that transfer said water flow, water energy and/or water quality data, using encryption and identification technology to an internet connection;	'390 Col. 11, lines 7-25 - In an embodiment of the valve meter assembly 1000, the wireless communication unit 2310 may receive signals from the remotely located communicator, or send signals to the remotely located communicator, or both. The wireless communication unit 2310 may include a wireless communication unit circuit 2925 (shown in FIG. 29) as part of the PCB 2450. The wireless communication unit circuit 2925 receives signals from the remotely located communicator. Neither '120, '063, '390 nor '607 disclose any access points nor any encryption or identification technology to an internet connection.

said water flow, water energy and/or water quality data transferred over the internet connection to one or more remote computers or computer servers, and;	'390 Col. 11, lines 17-22 - The remotely located communicator may be any communication device or system including a computer, a server, a gateway, another valve meter assembly, a handheld device, a mesh network, or any other device or system capable of communicating with the wireless communication unit 2310. '732 Fig. 3a, 3b, 4, 5, 6, 8 Col. 13, lines 17-39
said remote computers or servers allow registered owners and users to access their registered water flow, water energy and/or water quality data using a cell phone, smart phone, mobile phone, or a mobile electronic communication device.	Neither '120, '063, or '390 disclose any means to allow registered owners and users to access their registered water flow, water energy and/or water quality data using a cell phone, smart phone, ~~or~~ mobile phone, or a mobile electronic communication device.
'792 Claim 2 CC7	
a base station in close proximity to a main water supply;	'120 Abstract - Methods and systems are disclosed for monitoring water leaks within a home. A home network with various devices monitors these devices with a controller. '063 Abstract – This invention is a water consumption monitoring and control system comprised of a base unit, itself compromising a display and data entry device, a microprocessor, a communication like to water meters, pressure sensors, temperature sensors and shut off valve. In addition, the base unit has access to the Internet and can access a server which holds a database of water conservation information. The database includes watering advisories from local government, and weather information from the weather office. '390 Abstract - A valve meter device, assembly, and method is disclosed including a housing defining at least one inlet opening and at least one outlet opening and a channel connecting the openings, the at least one inlet opening having an inlet end and the at least one outlet opening having an outlet end; a water meter positioned in the channel, the water meter configured to monitor a flow of water through the valve meter device. '607 Abstract - A microprocessor based control system to monitor flow in a potable water system and compare said flow with pre-set programs of time of day and duration of flow, if the pre-set parameters are exceeded the controller will turn off the flow of water.

said base station includes a joint means for connecting to a cold/ambient water supply, or a joint means for connecting to a cold/ambient water supply and a joint means for connecting to a hot water supply, said base station have a joint means for connecting to outgoing water supply line(s) for a home residence, company or building structure;	'120 Col. 3, line 36-40 - A main water meter 52 is operatively connected to the main water inlet pipe 50 for measuring a total amount of water flow into the home and communicating information gathered to the controller 10 via a communication module 56. '063 Col. 3, line 36-40 - A main water meter 52 is operatively connected to the main water inlet pipe 50 for measuring a total amount of water flow into the home '390 Col. 4, lines 31-33 - As illustrated in FIG. 3, the device housing 110 has an inlet 310 and an outlet 320. Water flows through the device housing 110 by flowing into the inlet 310 and the out of the outlet 320. '607 Col. 3, lines 31-33 - Referring to FIGS. 1, 2 and 5 of the drawings, a fluid flow detection and shut-off system of the invention can be seen for use in residential of commercial structures.
said base station further comprising a first power supply, said first power supply is either AC powered, DC powered, or powered with one or more batteries, said first power supply electrically connected to a first circuitry which has one or more microprocessors or microcontrollers;	'120 Col. 2, lines 60-67 - The controller 10 includes a microprocessor, which is programmed to selectively send and/or receive signals to a device control board 24 and 26 of devices 12 and 14, for example, in response to the input signal it receives. '063 Col. 2, lines 60-67 - The controller 10 includes a microprocessor, which is programmed to selectively send and/or receive signals to a device control board 24 and 26 of devices 12 and 14, for example, in response to the input signal it receives. '390 Col. 11, lines 36-42 - Enclosed within the plastic cover 2320a, b is a sealing gasket 2420, a battery 2430, a transceiver 2440, and a printed circuit board (PCB) 2450. Where a "printed circuit board" or PCB is included in the current description, any circuitry which functions as the PCB is intended to be included in alternative embodiments as a variant of a printed circuit board. 067 Col. 3, lines 35-40 The shut-off system of the invention has a main control unit 10 with power supplied by a step down transformer 11 from a live power source of 110 volt AC to a transformer output at 13 of 12 volts DC which supplies the main controller 10 of the system

one or more water flow sensors in communication with a water supply, said one or more water flow sensors in electrical connection with a first electrical circuity;	'120 Col.3, lines 52-55 - … includes at least one water meter or flow meter for measuring water that is consumed by a water consuming device and communicating information gathered to the controller 10 via a communication module 56. '063 Paragraph 0048 - A series of sensors including water temperature sensors 3, water pressure sensors 8, floor moisture sensors 7, vibration flush sensors 5, water meters 2, 4, rain sensors/gauge 16. ' '390 Col. 11, lines 36-42 - Enclosed within the plastic cover 2320a, b is a sealing gasket 2420, a battery 2430, a transceiver 2440, and a printed circuit board (PCB) 2450. Where a "printed circuit board" or PCB is included in the current description, any circuitry which functions as the PCB is intended to be included in alternative embodiments as a variant of a printed circuit board. 390 Col. 10, lines 38-52 - Internal to the meter is a nutating disc 2110 that interfaces with an output register interaction shaft 2120. The nutating disc 2110 includes a disc pin 2115 which engages the output register interaction shaft 2120. In operation, the nutating disc 2110 and disc pin 2115 wobble about a fixed point in the meter to drive the output register interaction shaft 2120. The output register interaction shaft 2120 is attached to a meter magnet 2130. The meter magnet 2130 has a four-pole arrangement that coordinates with a register 2220 (shown in FIG. 22) such that when the meter magnet 2130 turns the register 2220 logs the motion and provides a readout of water usage. '607 Col. 4, lines 10-24 - Referring now to FIG. 3 of the drawings, the flow sensor 18 can be seen having a valve body 30 with an inlet opening 31 and an oppositely disposed outlet opening 32. A valve seat 33 is formed between the inlet and outlet openings with a ball valve element 34 movable within valve guides 35. A leaf type spring 36 extends from the control head 43 and is engageable against the valve ball element 34 urging same into the valve seat 33. A back pressure port 37 upstream of the valve ball element 34 communicates with a chamber 38 having a magnetized piston 39 and a calibrated spring 40. A back pressure outlet port 41 communicates with the chamber 38 allowing for movement of the magnetized piston 39 against the spring 40 when flow occurs indicated by the arrows in broken lines and the ball element

	position at 34A. The flow sensor disclosed in Fig 3 and column 4, lines 10-39 is non-typical custom design and not it is not clear to one skill in the art that this custom design can accurately monitor the actual water flow rate. It may be a binary flow sensor design monitoring only flow or no flow.
said base station monitors and processes water parameter data including water flow, water energy, and/or water quality data;	
said base station includes software that controls and sequences the water parameter data and prepares said data for wired or wireless transfer;	'390 Fig. 29, Col. 11, lines 12-22 The communication device in some embodiments may be a wireless communication unit 2310. In the current embodiment, the wireless communication unit 2310 is part of a mesh network where the mesh network includes the remotely located communicator. The remotely located communicator may be operated by a municipality, a technician, a service provider, or another entity. The remotely located communicator may be any communication device or system including a computer, a server, a gateway, another valve meter assembly, a handheld device, a mesh network, or any other device or system capable of communicating with the wireless communication unit 2310.
a receiving station, said receiving station having a second electrical circuitry including one or more second microprocessors, said receiving station remotely located from said base station;	
said receiving station having a second power supply, said second power supply is either AC power, DC power, or powered with one or more batteries, said second power supply electrically connected to a second circuitry;	
said first electrical circuitry of said base station is in wire or wireless communication with said second electrical circuity of said receiving station;	
said receiving station designed to establish Wi-Fi, Bluetooth or ZigBee electrical communication with a wireless router/server, and/or cellular communication with a cell tower technology, and any combinations thereof;	

said receiving station includes mesh-enabled circuitry that can communicate with other receiving stations for transferring water flow, water energy and/or water quality data to one or more access points;	
said receiving station or a custom transfer apparatus functioning as one or more access points for transferring said water flow, water energy and/or water quality data over an internet connection to one or more remote computers or computer servers; and	
said computer servers allow registered owners and users to access their registered water flow, water energy and/or water quality data using a cell phone, smart phone, mobile phone or a mobile electronic communication device.	
'792 Claim 5, CC7	
5. The water use monitoring and leak detection apparatus of claim 1, further comprising said base station including an electronic water control valve wherein said base station is programmed to automatically turns off the main water supply when a leak is detected or alternately can send an alert signal when a leak is detected to ~~a~~ said cell phone, smart phone, mobile phone, or other mobile electronic communication device wherein a user is provided an election to send a command to the base station to control the electronic water control valve to turn off or leave on the main water supply.	'120 Abstract - A shut off valve can be triggered remotely when a request is received from the user, which closes the water pipeline to prevent water damage. Col. 5, lines 10-24 - … the system 8 includes shut off valves 58, 68, and 78 at respective pipelines 50, 60 and 70. The central controller 10 may receive input from the user or homeowner in response to the warning or message, and the user, for example, may respond with instructions to shut off the pipelines 50, 60, and/or 70 via the respective shut off valve 58, 68 and 78 '063 Abstract – This invention is a water consumption monitoring and control system comprised of a base unit, itself compromising a display and data entry device, a microprocessor, a communication like to water meters, pressure sensors, temperature sensors and shut off valve. In addition, the base unit has access to the Internet and can access a server which holds a database of water conservation information. The database includes watering advisories from local government, and weather information from the weather office. '390 Col. 3, lines 46-47 - The valve meter device 100 includes a water supply valve 170 and a water meter 210. Col. 8, lines 3-7 - The solenoid attachment portion 820 is dimensioned to define a solenoid chamber 940 between the solenoid 270 and the valve cover 120 when the solenoid 270 is

	attached to the valve cover 120. Col. 16, lines 21- The wireless communication unit circuit 2925 may be configured to log the status of the solenoid 270. For example, the communication unit circuit 2925 may log whether the solenoid 270 is in the closed or open position. Also see Ball Col. 16, lines … water supply valve 170 is in a dynamic state between open and closed. '607 Col. 3, lines 35-40 The shut-off system of the invention has a main control unit 10 with power supplied by a step down transformer 11 from a live power source of 110 volt AC to a transformer output at 13 of 12 volts DC which supplies the main controller 10 of the system, Col. 3, lines 31-33 - Referring to FIGS. 1, 2 and 5 of the drawings, a fluid flow detection and shut-off system of the invention can be seen for use in residential of commercial structures. Petitioner contends that the undefined shut-off valve of '120, the water supply valve of '063 the solenoid valve of '390 and the on/off valve of '607 is not a ball valve design as disclosed and claimed by the present application and thus does not have any capability to perform variable water flow settings.
'792 Claim 7 CC7	
7. The water use monitoring and leak detection apparatus of claim 1, further comprising a water use calibration mode for learning the patterns and signature of water use devices within a home, corporation, building or structure.	
'792 Claim 8 CC7	
8. The water use monitoring and leak detection apparatus of claim 1, further comprising automatic learning mode whereby learning software privately tracks an owner's water flow and volume use for a period, assigning water patterns and water signatures to each specific water use device.	

'792 Claim 9 CC7	
9. The water use monitoring and leak detection apparatus of claim 2, further comprising a water use calibration mode for learning the patterns and signature of water use devices within a home, corporation, building or structure.	
'792 Claim 10 CC7	
10. The water use monitoring and leak detection apparatus of claim 2, further comprising automatic learning mode whereby learning software privately tracks an owner's water flow and volume use for a period, assigning water patterns and water signatures to each specific water use device.	
'792 Claim 12 CC7	
12. The water use monitoring and leak detection apparatus of claim 1, further comprising a water control means or a variable water flow means, said water control means or variable water flow means ~~is~~ controlled by programming instructions from said microprocessor or microcontroller for turning on and off said water control means or setting a variable water flow means, said water control means or variable water flow means can be activated by an owner's or user's cell phone, smart phones, ~~or~~ mobile phone, or other mobile electronic communication device, or by a remote apparatus or computer or alternately activated by said one or more wireless or wired means controlled by a municipality or governmental agency.	'120 Abstract - A shut off valve can be triggered remotely when a request is received from the user, which closes the water pipeline to prevent water damage. Col. 5, lines 10-24 - … the system 8 includes shut off valves 58, 68, and 78 at respective pipelines 50, 60 and 70. The central controller 10 may receive input from the user or homeowner in response to the warning or message, and the user, for example, may respond with instructions to shut off the pipelines 50, 60, and/or 70 via the respective shut off valve 58, 68 and 78 '063 Abstract – This invention is a water consumption monitoring and control system comprised of a base unit, itself compromising a display and data entry device, a microprocessor, a communication like to water meters, pressure sensors, temperature sensors and shut off valve. In addition, the base unit has access to the Internet and can access a server which holds a database of water conservation information. The database includes watering advisories from local government, and weather information from the weather office. '390 Col. 3, lines 46-47 - The valve meter device 100 includes a water supply valve 170 and a water meter 210. Col. 8, lines 3-7 - The solenoid attachment portion 820 is dimensioned to define a solenoid chamber 940 between the solenoid 270 and the valve cover 120 when the solenoid 270 is attached to the valve cover 120. Col. 16, lines 21- The wireless communication unit circuit 2925 may be configured to log the status of the solenoid 270. For example, the communication unit circuit 2925 may log whether the solenoid 270 is in the closed

	or open position. Also see Ball Col. 16, lines … water supply valve 170 is in a dynamic state between open and closed. '607 Col. 3, lines 35-40 The shut-off system of the invention has a main control unit 10 with power supplied by a step down transformer 11 from a live power source of 110 volt AC to a transformer output at 13 of 12 volts DC which supplies the main controller 10 of the system, Col. 3, lines 31-33 - Referring to FIGS. 1, 2 and 5 of the drawings, a fluid flow detection and shut-off system of the invention can be seen for use in residential of commercial structures. Petitioner contends that the undefined shut-off valve of '120, the water supply valve of '063 the solenoid valve of '390 and the on/off valve of '607 is not a ball valve design as disclosed and claimed by the present application and thus does not have any capability to perform variable water flow settings.
'792 Claim 14 CC7	
14. The water use monitoring and leak detection apparatus of claim 2, further comprising a water shut control means or a variable water flow means, said water control means or variable water flow means controlled by programming instructions from said microprocessor or microcontroller for turning on and off said water control means or setting a variable water flow means, said water control means or variable water flow means can be activated by an owner's or user's cell phone, smart phones, mobile phone, or other mobile electronic communication device, or by a remote apparatus or computer or alternately activated by said one or more wireless or wired means controlled by a municipality or governmental agency.	
'792 Claim 17 CC7	
17. The water use monitoring and leak detection apparatus of claim 1, wherein the base station can be incorporated into or serve as the pressure regulator or primary water meter at a residential home or commercial facility.	
'792 Claim 19 CC7	
19. The water use monitoring and leak detection apparatus of claim 2, wherein the base station can be incorporated into or serve as the pressure regulator or primary water meter at a residential home or commercial facility.	

'792 Claim 23 CC7	
23. The water use monitoring and leak detection apparatus of claim 2, further comprising said base station including an electronic water control valve wherein said base station is programmed to automatically turns off the main water supply when a leak is detected or alternately can send an alert signal when a leak is detected to ~~a~~ said cell phone, smart phone, mobile phone, or other mobile electronic communication device whereby a user is provided an election to send a command to the base station to control the electronic water control valve to turn off or leave on the main water supply.	
'792 Claim 28 CC7	
28. The water use monitoring apparatus of claim 1, further compromising one or more pressure sensors, said one or more pressure sensors in electrical connection with said first electrical circuity.	Paragraph 0048 - A series of sensors including water temperature sensors 3, water pressure sensors 8, floor moisture sensors 7, vibration flush sensors 5, water meters 2, 4, rain sensors/gauge 16.
'792 Claim 29 CC7	
29. The water use monitoring and leak detection apparatus of claim 1, further compromising one or more temperature sensors, said one or more temperature sensors in electrical connection with said first electrical circuity.	Paragraph 0048 - A series of sensors including water temperature sensors 3, water pressure sensors 8, floor moisture sensors 7, vibration flush sensors 5, water meters 2, 4, rain sensors/gauge 16.
'792 Claim 31 CC7	
31. The water use monitoring and leak detection apparatus of claim 2, further comprising one or more pressure sensors, said one or more pressure sensors in electrical connection with said first electrical circuity.	
'792 Claim 32 CC7	
32. The water use monitoring and leak detection apparatus of claim 2, further comprising one or more temperature sensors, said one or more temperature sensors in electrical connection with said first electrical circuity.	

<u>CC11</u>

US. Patent 9,749,792 Claim Chart - Olson 8,878,690

'792 Claim 1 CC11	
A water use and monitoring and leak detection apparatus comprising:	Abstract - The invention provides a method and several types of devices for converting meter reading signals into data messages including a first message (40) having meter data (44) representing consumption of a utility, and meter diagnostic status data (43), and a second message (60) having meter reverse flow data (63-65) and meter diagnostic data (66) particular to an electronic flow meter, and receiving said first message (40) and said second message (60) and converting first message and said second message to radio frequency signals (25) and transmitting said radio frequency signals (25) to a receiver (22, 24).
a base station designed to be connected to a main water supply means;	Fig. 2, 3, 4 and 5
said base station includes a joint means for connecting to a cold/ambient water supply, or a joint means for connecting to a cold/ambient water supply and a joint means for connecting to a hot water supply, said base station have a joint means for connecting to outgoing water supply line(s) for a home residence, company or building structure;	Fig. 2, 3, 4 and 5
electrical circuitry including one or more microprocessors or microcontrollers with a power source contained with said base station apparatus;	Fig. 7, Col. 4 lines 3-8 Referring to FIG. 7, the housing 20' in FIGS. 3 and 5, encloses an electrical signal processing section 50 typically formed on a circuit board 26 and including a microelectronic CPU 51 operating according to a control program of program instructions stored in a program memory 52, which may be internal to the CPU 51.
said power source is either AC powered, DC powered, or powered with one or more batteries, said power source is electrically connected to said electrical circuitry;	Fig. 7, Col. 4 lines 3-8 Referring to FIG. 7, the housing 20' in FIGS. 3 and 5, encloses an electrical signal processing section 50 typically formed on a circuit board 26 and including a microelectronic CPU 51 operating according to a control program of program instructions stored in a program memory 52, which may be internal to the CPU 51.

one or more flow sensors in communication with a water supply, said one or more flow sensors in electrical communication with said electrical circuitry;	Fig. 5, Col. 3 lines 43-60 Referring to FIG. 5, in the integrated meter, meter register and transmitter (FIG. 3 version), the meter housing 16 is made of brass or another suitable material, preferably lead-free, to withstand water pressures. Inside the housing 16 is a plastic metering insert 38 positioned in the conduit 16 and supporting two mirrors 32, 33 at minus forty-five degrees and plus forty-five degrees, respectively, relative to vertical. The assembly also includes two ultrasonic transducers 30, 31, a temperature sensor 39, a signal processing section, 50, and one or more batteries 37. A first ultrasonic signal will be transmitted through one of the transducers 30 downward, to reflect off one of the mirrors 32 at ninety degrees, to travel through the flow stream 35 as an ultrasonic signal parallel to the flow stream and the meter housing 16, which is shaped like a pipe. The signal will then reflect off the second mirror 33 at ninety degrees and be detected by the second ultrasonic transducer 31 and converted to an input to the signal processing section 50 in FIG. 7. A second signal is then transmitted in a reverse direction through second one of the transducers 31, downward to reflect off the second one of the mirrors 33 at ninety degrees to travel through the flow stream 35 opposite the direction of flow 35 and parallel to the direction of flow and the conduit 16. The signal will then reflect off the first-mentioned mirror 32 at ninety degrees and be detected by the first ultrasonic transducer 30 and input to the signal processing section 50 in FIG. 7.
one or more wired or wireless electrical communication means, said or wired wireless electrical communication means having the capability to transfer water parameter, water energy and/or water quality information or data to one or more remote apparatuses, said wired or wireless electrical communication means utilizes protection technology to securely provide water use, water energy and/or water quality information and/or data in a confidential format;	Col. 3, lines 22-25 …In a fully "integrated version" of the invention seen in FIG. 3, a housing 20' encloses both meter register and transmitter formed on a circuit board 26 with an antenna 29 for transmitting signals directly through the pit lid 15 to a radio signal receiver 24.**Does not disclose transferring water use data in a confidential format.**
said base station includes mesh-enabled circuitry that can communicate with other base stations for transferring water flow, water energy and/or water quality data;	

said base station(s) functioning as one or more access points that transfer said water flow, water energy and/or water quality data, using encryption and identification technology to an internet connection;	
said water flow, water energy and/or water quality data transferred over the internet connection to one or more remote computers or computer servers, and;	
said remote computers or servers allow registered owners and users to access their registered water flow, water energy and/or water quality data using a cell phone, smart phone, mobile phone, or a mobile electronic communication device.	
'792 Claim 2 CC11	
a base station in close proximity to a main water supply;	Abstract - The invention provides a method and several types of devices for converting meter reading signals into data messages including a first message (40) having meter data (44) representing consumption of a utility, and meter diagnostic status data (43), and a second message (60) having meter reverse flow data (63-65) and meter diagnostic data (66) particular to an electronic flow meter, and receiving said first message (40) and said second message (60) and converting first message and said second message to radio frequency signals (25) and transmitting said radio frequency signals (25) to a receiver (22, 24).
said base station includes a joint means for connecting to a cold/ambient water supply, or a joint means for connecting to a cold/ambient water supply and a joint means for connecting to a hot water supply, said base station have a joint means for connecting to outgoing water supply line(s) for a home residence, company or building structure;	Fig. 2, 3, 4 and 5
said base station further comprising a first power supply, said first power supply is either AC powered, DC powered, or powered with one or more batteries, said first power supply electrically connected to a first circuitry which has one or more microprocessors or microcontrollers;	Fig. 7, Col. 4 lines 3-8 Referring to FIG. 7, the housing 20' in FIGS. 3 and 5, encloses an electrical signal processing section 50 typically formed on a circuit board 26 and including a microelectronic CPU 51 operating according to a control program of program instructions stored in a program memory 52, which may be internal to the CPU 51.

one or more water flow sensors in communication with a water supply, said one or more water flow sensors in electrical connection with a first electrical circuity;	Fig. 5, Col. 3 lines 43-60 Referring to FIG. 5, in the integrated meter, meter register and transmitter (FIG. 3 version), the meter housing 16 is made of brass or another suitable material, preferably lead-free, to withstand water pressures. Inside the housing 16 is a plastic metering insert 38 positioned in the conduit 16 and supporting two mirrors 32, 33 at minus forty-five degrees and plus forty-five degrees, respectively, relative to vertical. The assembly also includes two ultrasonic transducers 30, 31, a temperature sensor 39, a signal processing section, 50, and one or more batteries 37. A first ultrasonic signal will be transmitted through one of the transducers 30 downward, to reflect off one of the mirrors 32 at ninety degrees, to travel through the flow stream 35 as an ultrasonic signal parallel to the flow stream and the meter housing 16, which is shaped like a pipe. The signal will then reflect off the second mirror 33 at ninety degrees and be detected by the second ultrasonic transducer 31 and converted to an input to the signal processing section 50 in FIG. 7. A second signal is then transmitted in a reverse direction through second one of the transducers 31, downward to reflect off the second one of the mirrors 33 at ninety degrees to travel through the flow stream 35 opposite the direction of flow 35 and parallel to the direction of flow and the conduit 16. The signal will then reflect off the first-mentioned mirror 32 at ninety degrees and be detected by the first ultrasonic transducer 30 and input to the signal processing section 50 in FIG. 7.
said base station monitors and processes water parameter data including water flow, water energy, and/or water quality data;	
said base station includes software that controls and sequences the water parameter data and prepares said data for wired or wireless transfer;	
a receiving station, said receiving station having a second electrical circuitry including one or more second microprocessors, said receiving station remotely located from said base station;	

said receiving station having a second power supply, said second power supply is either AC power, DC power, or powered with one or more batteries, said second power supply electrically connected to a second circuitry;	
said first electrical circuitry of said base station is in wire or wireless communication with said second electrical circuity of said receiving station;	
said receiving station designed to establish Wi-Fi, Bluetooth or ZigBee electrical communication with a wireless router/server, and/or cellular communication with a cell tower technology, and any combinations thereof;	
said receiving station includes mesh-enabled circuitry that can communicate with other receiving stations for transferring water flow, water energy and/or water quality data to one or more access points;	
said receiving station or a custom transfer apparatus functioning as one or more access points for transferring said water flow, water energy and/or water quality data over an internet connection to one or more remote computers or computer servers; and	
said computer servers allow registered owners and users to access their registered water flow, water energy and/or water quality data using a cell phone, smart phone, mobile phone or a mobile electronic communication device.	
'792 Claim 5 CC11	
5. The water use monitoring and leak detection apparatus of claim 1, further comprising said base station including an electronic water control valve wherein said base station is programmed to automatically turns off the main water supply when a leak is detected or alternately can send an alert signal when a leak is detected to ~~a~~ said cell phone, smart phone, mobile phone, or other mobile electronic communication device wherein a user is provided an election to send a command to the base station to control the electronic water control valve to turn off or leave on the main water supply.	

'792 Claim 7 CC11	
7. The water use monitoring and leak detection apparatus of claim 1, further comprising a water use calibration mode for learning the patterns and signature of water use devices within a home, corporation, building or structure.	
'792 Claim 8 CC11	
8. The water use monitoring and leak detection apparatus of claim 1, further comprising automatic learning mode whereby learning software privately tracks an owner's water flow and volume use for a period, assigning water patterns and water signatures to each specific water use device.	
'792 Claim 9 CC11	
9. The water use monitoring and leak detection apparatus of claim 2, further comprising a water use calibration mode for learning the patterns and signature of water use devices within a home, corporation, building or structure.	
'792 Claim 10 CC11	
10. The water use monitoring and leak detection apparatus of claim 2, further comprising automatic learning mode whereby learning software privately tracks an owner's water flow and volume use for a period, assigning water patterns and water signatures to each specific water use device.	
'792 Claim 12 CC11	
12. The water use monitoring and leak detection apparatus of claim 1, further comprising a water control means or a variable water flow means, said water control means or variable water flow means ~~is~~ controlled by programming instructions from said microprocessor or microcontroller for turning on and off said water control means or setting a variable water flow means, said water control means or variable water flow means can be activated by an owner's or user's cell phone, smart phones, ~~or~~ mobile phone, or other mobile electronic communication device, or by a remote apparatus or computer or alternately activated by said one or more wireless or wired means controlled by a municipality or governmental agency.	

'792 Claim 14 CC11	
14. The water use monitoring and leak detection apparatus of claim 2, further comprising a water shut control means or a variable water flow means, said water control means or variable water flow means controlled by programming instructions from said microprocessor or microcontroller for turning on and off said water control means or setting a variable water flow means, said water control means or variable water flow means can be activated by an owner's or user's cell phone, smart phones, mobile phone, or other mobile electronic communication device, or by a remote apparatus or computer or alternately activated by said one or more wireless or wired means controlled by a municipality or governmental agency.	
'792 Claim 17 CC11	
17. The water use monitoring and leak detection apparatus of claim 1, wherein the base station can be incorporated into or serve as the pressure regulator or primary water meter at a residential home or commercial facility.	
'792 Claim 19 CC11	
19. The water use monitoring and leak detection apparatus of claim 2, wherein the base station can be incorporated into or serve as the pressure regulator or primary water meter at a residential home or commercial facility.	
'792 Claim 23 CC11	
23. The water use monitoring and leak detection apparatus of claim 2, further comprising said base station including an electronic water control valve wherein said base station is programmed to automatically turns off the main water supply when a leak is detected or alternately can send an alert signal when a leak is detected to ~~a~~ said cell phone, smart phone, mobile phone, or other mobile electronic communication device whereby a user is provided an election to send a command to the base station to control the electronic water control valve to turn off or leave on the main water supply.	
'792 Claim 28 CC11	
28. The water use monitoring apparatus of claim 1, further compromising one or more pressure sensors, said one or more pressure sensors in electrical connection with said first electrical circuity.	

'792 Claim 29 CC11	
29. The water use monitoring and leak detection apparatus of claim 1, further compromising one or more temperature sensors, said one or more temperature sensors in electrical connection with said first electrical circuity.	Col. 3, lines 49-53 The assembly also includes two ultrasonic transducers 30, 31, a temperature sensor 39, a signal processing section, 50, and one or more batteries 37. Col. 4, lines 1-2 A temperature sensor 39 is also positioned with one end projecting into the flow stream 35.
'792 Claim 31 CC11	
31. The water use monitoring and leak detection apparatus of claim 2, further comprising one or more pressure sensors, said one or more pressure sensors in electrical connection with said first electrical circuity.	
'792 Claim 32 CC11	
32. The water use monitoring and leak detection apparatus of claim 2, further comprising one or more temperature sensors, said one or more temperature sensors in electrical connection with said first electrical circuity.	Col. 3, lines 49-53 The assembly also includes two ultrasonic transducers 30, 31, a temperature sensor 39, a signal processing section, 50, and one or more batteries 37. Col. 4, lines 1-2 A temperature sensor 39 is also positioned with one end projecting into the flow stream 35.

CC12

US. Patent 9,749,792 Claim Chart - Zigdon 7,012,546

'792 Claim 1 CC12	
A water use and monitoring and leak detection apparatus comprising:	Abstract - A one way direct sequence spread spectrum (DSSS) communications wide-area network is the data collection channel (uplink) of an automatic meter reading (AMR) system, and a paging network, or other suitable communication channel is the optional forward (downlink) channel.
a base station designed to be connected to a main water supply means;	
said base station includes a joint means for connecting to a cold/ambient water supply, or a joint means for connecting to a cold/ambient water supply and a joint means for connecting to a hot water supply, said base station have a joint means for connecting to outgoing water supply line(s) for a home residence, company or building structure;	
electrical circuitry including one or more microprocessors or microcontrollers with a power source contained with said base station apparatus;	Col. 5, lines 39-43 The meter module preferably is equipped with a power supply in which a capacitive element and a limited current source are combined, in order to allow high output power during a short transmission burst, which may also be initiated immediately in the event of a power outage. Col. 17 lines 40-44 The module 22 also includes a controller module 182, which typically is a microprocessor, connected to the interface logic module 180 by way of connector 184 and connected to a serial data communication interface 186 by way of conductor 188.
said power source is either AC powered, DC powered, or powered with one or more batteries, said power source is electrically connected to said electrical circuitry;	Col. 5, lines 39-43 The meter module preferably is equipped with a power supply in which a capacitive element and a limited current source are combined, in order to allow high output power during a short transmission burst, which may also be initiated immediately in the event of a power outage. Col. 17 lines 40-44 The module 22 also includes a controller module 182, which typically is a microprocessor, connected to the interface logic module 180 by way of connector 184 and connected to a serial data communication interface 186 by way of conductor 188.
one or more flow sensors in communication with a water supply, said one or more flow sensors in electrical communication with said electrical circuitry;	Col. 5, lines 33-38 The invention provides a low-cost, high-output-power meter module, which may operate in the system described above. The module includes a sensor, data storage and processing, a direct sequence spread spectrum

	transmitter which may have an output of between 0.5 and 1.0 watt, and an antenna, all within the same physical enclosure
one or more wired or wireless electrical communication means, said or wired wireless electrical communication means having the capability to transfer water parameter, water energy and/or water quality information or data to one or more remote apparatuses, said wired or wireless electrical communication means utilizes protection technology to securely provide water use, water energy and/or water quality information and/or data in a confidential format;	Abstract - The communications network may include one-way meter modules (transmitters) each communicatively coupled to a corresponding electric, gas or water utility meter, and may include two-way meter modules (transceivers) each coupled to such a corresponding utility meter. The meter modules monitor, store, encode and periodically transmit metering data via radio signals (air messages) in an appropriate RF channel. Metering data air messages are collected by a network of receiver Base Stations (BS) and forwarded to a Data Operations Center (DOC), which acts as a metering data gateway. **Does not disclose transferring water use data in a confidential format.**
said base station includes mesh-enabled circuitry that can communicate with other base stations for transferring water flow, water energy and/or water quality data;	
said base station(s) functioning as one or more access points that transfer said water flow, water energy and/or water quality data, using encryption and identification technology to an internet connection;	
said water flow, water energy and/or water quality data transferred over the internet connection to one or more remote computers or computer servers, and;	The network components of the system of the invention include one-way (transmit only) and two-way (transmit and receive) meter modules, which monitor, store, encode and periodically transmit metering data via radio signals (air messages). Also included are receiver base stations, which receive, decode, store and forward metering data to a central database and metering data gateway, referred to as the Data Operations Center (DOC). Base stations do not perform any meter data processing, but simply transfer decoded air messages to the DOC. The data operations center communicates with all of the network's base stations and receives decoded air messages from the base stations. The DOC processes, validates and stores metering data in a meter database that it maintains for the entire meter population operating in the network and has the capability to export or forward metering data to other systems via standard data protocols.

said remote computers or servers allow registered owners and users to access their registered water flow, water energy and/or water quality data using a cell phone, smart phone, mobile phone, or a mobile electronic communication device.	
'792 Claim 2 CC12	
a base station in close proximity to a main water supply;	
said base station includes a joint means for connecting to a cold/ambient water supply, or a joint means for connecting to a cold/ambient water supply and a joint means for connecting to a hot water supply, said base station have a joint means for connecting to outgoing water supply line(s) for a home residence, company or building structure;	
said base station further comprising a first power supply, said first power supply is either AC powered, DC powered, or powered with one or more batteries, said first power supply electrically connected to a first circuitry which has one or more microprocessors or microcontrollers;	Col. 5, lines 39-43 The meter module preferably is equipped with a power supply in which a capacitive element and a limited current source are combined, in order to allow high output power during a short transmission burst, which may also be initiated immediately in the event of a power outage. Col. 17 lines 40-44 The module 22 also includes a controller module 182, which typically is a microprocessor, connected to the interface logic module 180 by way of connector 184 and connected to a serial data communication interface 186 by way of conductor 188.
one or more water flow sensors in communication with a water supply, said one or more water flow sensors in electrical connection with a first electrical circuity;	Col. 5, lines 39-43 The meter module preferably is equipped with a power supply in which a capacitive element and a limited current source are combined, in order to allow high output power during a short transmission burst, which may also be initiated immediately in the event of a power outage. Col. 17 lines 40-44 The module 22 also includes a controller module 182, which typically is a microprocessor, connected to the interface logic module 180 by way of connector 184 and connected to a serial data communication interface 186 by way of conductor 188.
said base station monitors and processes water parameter data including water flow, water energy, and/or water quality data;	

said base station includes software that controls and sequences the water parameter data and prepares said data for wired or wireless transfer;	
a receiving station, said receiving station having a second electrical circuitry including one or more second microprocessors, said receiving station remotely located from said base station;	
said receiving station having a second power supply, said second power supply is either AC power, DC power, or powered with one or more batteries, said second power supply electrically connected to a second circuitry;	
said first electrical circuitry of said base station is in wire or wireless communication with said second electrical circuity of said receiving station;	
said receiving station designed to establish Wi-Fi, Bluetooth or ZigBee electrical communication with a wireless router/server, and/or cellular communication with a cell tower technology, and any combinations thereof;	
said receiving station includes mesh-enabled circuitry that can communicate with other receiving stations for transferring water flow, water energy and/or water quality data to one or more access points;	
said receiving station or a custom transfer apparatus functioning as one or more access points for transferring said water flow, water energy and/or water quality data over an internet connection to one or more remote computers or computer servers; and	
said computer servers allow registered owners and users to access their registered water flow, water energy and/or water quality data using a cell phone, smart phone, mobile phone or a mobile electronic communication device.	

'792 Claim 5 CC12	
5. The water use monitoring and leak detection apparatus of claim 1, further comprising said base station including an electronic water control valve wherein said base station is programmed to automatically turns off the main water supply when a leak is detected or alternately can send an alert signal when a leak is detected to ~~a~~ said cell phone, smart phone, mobile phone, or other mobile electronic communication device wherein a user is provided an election to send a command to the base station to control the electronic water control valve to turn off or leave on the main water supply.	
'792 Claim 7 CC12	
7. The water use monitoring and leak detection apparatus of claim 1, further comprising a water use calibration mode for learning the patterns and signature of water use devices within a home, corporation, building or structure.	
'792 Claim 8 CC12	
8. The water use monitoring and leak detection apparatus of claim 1, further comprising automatic learning mode whereby learning software privately tracks an owner's water flow and volume use for a period, assigning water patterns and water signatures to each specific water use device.	
'792 Claim 9 CC12	
9. The water use monitoring and leak detection apparatus of claim 2, further comprising a water use calibration mode for learning the patterns and signature of water use devices within a home, corporation, building or structure.	
'792 Claim 10 CC12	
10. The water use monitoring and leak detection apparatus of claim 2, further comprising automatic learning mode whereby learning software privately tracks an owner's water flow and volume use for a period, assigning water patterns and water signatures to each specific water use device.	

'792 Claim 12 CC12	
12. The water use monitoring and leak detection apparatus of claim 1, further comprising a water control means or a variable water flow means, said water control means or variable water flow means ~~is~~ controlled by programming instructions from said microprocessor or microcontroller for turning on and off said water control means or setting a variable water flow means, said water control means or variable water flow means can be activated by an owner's or user's cell phone, smart phones, ~~or~~ mobile phone, or other mobile electronic communication device, or by a remote apparatus or computer or alternately activated by said one or more wireless or wired means controlled by a municipality or governmental agency.	
'792 Claim 14 CC12	
14. The water use monitoring and leak detection apparatus of claim 2, further comprising a water shut control means or a variable water flow means, said water control means or variable water flow means controlled by programming instructions from said microprocessor or microcontroller for turning on and off said water control means or setting a variable water flow means, said water control means or variable water flow means can be activated by an owner's or user's cell phone, smart phones, mobile phone, or other mobile electronic communication device, or by a remote apparatus or computer or alternately activated by said one or more wireless or wired means controlled by a municipality or governmental agency.	
'792 Claim 17 CC12	
17. The water use monitoring and leak detection apparatus of claim 1, wherein the base station can be incorporated into or serve as the pressure regulator or primary water meter at a residential home or commercial facility.	
'792 Claim 19 CC12	
19. The water use monitoring and leak detection apparatus of claim 2, wherein the base station can be incorporated into or serve as the pressure regulator or primary water meter at a residential home or commercial facility.	

'792 Claim 23 CC12	
23. The water use monitoring and leak detection apparatus of claim 2, further comprising said base station including an electronic water control valve wherein said base station is programmed to automatically turns off the main water supply when a leak is detected or alternately can send an alert signal when a leak is detected to ~~a~~ said cell phone, smart phone, mobile phone, or other mobile electronic communication device whereby a user is provided an election to send a command to the base station to control the electronic water control valve to turn off or leave on the main water supply.	
'792 Claim 28 CC12	
28. The water use monitoring apparatus of claim 1, further compromising one or more pressure sensors, said one or more pressure sensors in electrical connection with said first electrical circuity.	
'792 Claim 29 CC12	
29. The water use monitoring and leak detection apparatus of claim 1, further compromising one or more temperature sensors, said one or more temperature sensors in electrical connection with said first electrical circuity.	Fig. 5, Paragraphs 15, 40, 44, 48, 68, 75, and 81
'792 Claim 31 CC12	
31. The water use monitoring and leak detection apparatus of claim 2, further comprising one or more pressure sensors, said one or more pressure sensors in electrical connection with said first electrical circuity.	
'792 Claim 32 CC12	
32. The water use monitoring and leak detection apparatus of claim 2, further comprising one or more temperature sensors, said one or more temperature sensors in electrical connection with said first electrical circuity.	

CC13

US. Patent 9,749,792 Claim Chart - Zigdon 8,269,651

'792 Claim 1 CC13	
A water use and monitoring and leak detection apparatus comprising:	Abstract - A one way direct sequence spread spectrum (DSSS) communications wide-area network is the data collection channel (uplink) of an automatic meter reading (AMR) system, and a paging network, or other suitable communication channel is the optional forward (downlink) channel.
a base station designed to be connected to a main water supply means;	
said base station includes a joint means for connecting to a cold/ambient water supply, or a joint means for connecting to a cold/ambient water supply and a joint means for connecting to a hot water supply, said base station have a joint means for connecting to outgoing water supply line(s) for a home residence, company or building structure;	
electrical circuitry including one or more microprocessors or microcontrollers with a power source contained with said base station apparatus;	Col. 5, lines 39-43 The meter module preferably is equipped with a power supply in which a capacitive element and a limited current source are combined, in order to allow high output power during a short transmission burst, which may also be initiated immediately in the event of a power outage. Col. 17 lines 7-11 The module 22 also includes a controller module 182, which typically is a microprocessor, connected to the interface logic module 180 by way of connector 184 and connected to a serial data communication interface 186 by way of conductor 188.
said power source is either AC powered, DC powered, or powered with one or more batteries, said power source is electrically connected to said electrical circuitry;	Col. 5, lines 39-43 The meter module preferably is equipped with a power supply in which a capacitive element and a limited current source are combined, in order to allow high output power during a short transmission burst, which may also be initiated immediately in the event of a power outage. Col. 17 lines 7-11 The module 22 also includes a controller module 182, which typically is a microprocessor, connected to the interface logic module 180 by way of connector 184 and connected to a serial data communication interface 186 by way of conductor 188.
one or more flow sensors in communication with a water supply, said one or more flow sensors in electrical communication with said electrical circuitry;	Col. 16, lines 47-49 Each meter module in the network continuously monitors the resource consumption according to an input sensor that is coupled to the utility meter.

one or more wired or wireless electrical communication means, said or wired wireless electrical communication means having the capability to transfer water parameter, water energy and/or water quality information or data to one or more remote apparatuses, said wired or wireless electrical communication means utilizes protection technology to securely provide water use, water energy and/or water quality information and/or data in a confidential format;	Abstract - The communications network may include one-way meter modules (transmitters) each communicatively coupled to a corresponding electric, gas or water utility meter, and may include two-way meter modules (transceivers) each coupled to such a corresponding utility meter. The meter modules monitor, store, encode and periodically transmit metering data via radio signals (air messages) in an appropriate RF channel. Metering data air messages are collected by a network of receiver Base Stations (BS) and forwarded to a Data Operations Center (DOC), which acts as a metering data gateway. **Does not disclose transferring water use data in a confidential format.**
said base station includes mesh-enabled circuitry that can communicate with other base stations for transferring water flow, water energy and/or water quality data;	
said base station(s) functioning as one or more access points that transfer said water flow, water energy and/or water quality data, using encryption and identification technology to an internet connection;	
said water flow, water energy and/or water quality data transferred over the internet connection to one or more remote computers or computer servers, and;	Col. 4, lines 42-58 The network components of the system of the invention include one-way (transmit only) and two-way (transmit and receive) meter modules, which monitor, store, encode and periodically transmit metering data via radio signals (air messages). Also included are receiver base stations, which receive, decode, store and forward metering data to a central database and metering data gateway, referred to as the Data Operations Center (DOC). Base stations do not perform any meter data processing, but simply transfer decoded air messages to the DOC. The data operations center communicates with all of the network's base stations and receives decoded air messages from the base stations. The DOC processes, validates and stores metering data in a meter database that it maintains for the entire meter population operating in the network and has the capability to export or forward metering data to other systems via standard data protocols.
said remote computers or servers allow registered owners and users to access their registered water flow, water energy and/or water quality data using a cell phone, smart phone, mobile phone, or a mobile electronic communication device.	

'792 Claim 2 CC13	
a base station in close proximity to a main water supply;	Abstract - A one way direct sequence spread spectrum (DSSS) communications wide-area network is the data collection channel (uplink) of an automatic meter reading (AMR) system, and a paging network, or other suitable communication channel is the optional forward (downlink) channel.
said base station includes a joint means for connecting to a cold/ambient water supply, or a joint means for connecting to a cold/ambient water supply and a joint means for connecting to a hot water supply, said base station have a joint means for connecting to outgoing water supply line(s) for a home residence, company or building structure;	
said base station further comprising a first power supply, said first power supply is either AC powered, DC powered, or powered with one or more batteries, said first power supply electrically connected to a first circuitry which has one or more microprocessors or microcontrollers;	Col. 5, lines 39-43 The meter module preferably is equipped with a power supply in which a capacitive element and a limited current source are combined, in order to allow high output power during a short transmission burst, which may also be initiated immediately in the event of a power outage. Col. 17 lines 7-11 The module 22 also includes a controller module 182, which typically is a microprocessor, connected to the interface logic module 180 by way of connector 184 and connected to a serial data communication interface 186 by way of conductor 188.
one or more water flow sensors in communication with a water supply, said one or more water flow sensors in electrical connection with a first electrical circuity;	Col. 16, lines 47-49 Each meter module in the network continuously monitors the resource consumption according to an input sensor that is coupled to the utility meter.
said base station monitors and processes water parameter data including water flow, water energy, and/or water quality data;	
said base station includes software that controls and sequences the water parameter data and prepares said data for wired or wireless transfer;	

a receiving station, said receiving station having a second electrical circuitry including one or more second microprocessors, said receiving station remotely located from said base station;	Turning now to a more detailed description of the invention, FIG. 1 illustrates a scalable and modular wireless fixed-base data collection system, or network 10, comprising at least one wireless meter module, such as a two-way (transceiver) module 12, at least one receiver site (base station) 14, and one central site (data operations center) 16, into which all metering data is collected
said receiving station having a second power supply, said second power supply is either AC power, DC power, or powered with one or more batteries, said second power supply electrically connected to a second circuitry;	
said first electrical circuitry of said base station is in wire or wireless communication with said second electrical circuity of said receiving station;	
said receiving station designed to establish Wi-Fi, Bluetooth or ZigBee electrical communication with a wireless router/server, and/or cellular communication with a cell tower technology, and any combinations thereof;	
said receiving station includes mesh-enabled circuitry that can communicate with other receiving stations for transferring water flow, water energy and/or water quality data to one or more access points;	
said receiving station or a custom transfer apparatus functioning as one or more access points for transferring said water flow, water energy and/or water quality data over an internet connection to one or more remote computers or computer servers; and	
said computer servers allow registered owners and users to access their registered water flow, water energy and/or water quality data using a cell phone, smart phone, mobile phone or a mobile electronic communication device.	

'792 Claim 5 CC13	
5. The water use monitoring and leak detection apparatus of claim 1, further comprising said base station including an electronic water control valve wherein said base station is programmed to automatically turns off the main water supply when a leak is detected or alternately can send an alert signal when a leak is detected to ~~a~~ said cell phone, smart phone, mobile phone, or other mobile electronic communication device wherein a user is provided an election to send a command to the base station to control the electronic water control valve to turn off or leave on the main water supply.	
'792 Claim 7 CC13	
7. The water use monitoring and leak detection apparatus of claim 1, further comprising a water use calibration mode for learning the patterns and signature of water use devices within a home, corporation, building or structure.	
'792 Claim 8 CC13	
8. The water use monitoring and leak detection apparatus of claim 1, further comprising automatic learning mode whereby learning software privately tracks an owner's water flow and volume use for a period, assigning water patterns and water signatures to each specific water use device.	
'792 Claim 9 CC13	
9. The water use monitoring and leak detection apparatus of claim 2, further comprising a water use calibration mode for learning the patterns and signature of water use devices within a home, corporation, building or structure.	
'792 Claim 10 CC13	
10. The water use monitoring and leak detection apparatus of claim 2, further comprising automatic learning mode whereby learning software privately tracks an owner's water flow and volume use for a period, assigning water patterns and water signatures to each specific water use device.	

'792 Claim 12 CC13	
12. The water use monitoring and leak detection apparatus of claim 1, further comprising a water control means or a variable water flow means, said water control means or variable water flow means ~~is~~ controlled by programming instructions from said microprocessor or microcontroller for turning on and off said water control means or setting a variable water flow means, said water control means or variable water flow means can be activated by an owner's or user's cell phone, smart phones, ~~or~~ mobile phone, or other mobile electronic communication device, or by a remote apparatus or computer or alternately activated by said one or more wireless or wired means controlled by a municipality or governmental agency.	
'792 Claim 14 CC13	
14. The water use monitoring and leak detection apparatus of claim 2, further comprising a water shut control means or a variable water flow means, said water control means or variable water flow means controlled by programming instructions from said microprocessor or microcontroller for turning on and off said water control means or setting a variable water flow means, said water control means or variable water flow means can be activated by an owner's or user's cell phone, smart phones, mobile phone, or other mobile electronic communication device, or by a remote apparatus or computer or alternately activated by said one or more wireless or wired means controlled by a municipality or governmental agency.	
'792 Claim 17 CC13	
17. The water use monitoring and leak detection apparatus of claim 1, wherein the base station can be incorporated into or serve as the pressure regulator or primary water meter at a residential home or commercial facility.	Abstract - Methods and systems are disclosed for monitoring water leaks within a home. A home network with various devices monitors these devices with a controller.
'792 Claim 19 CC13	
19. The water use monitoring and leak detection apparatus of claim 2, wherein the base station can be incorporated into or serve as the pressure regulator or primary water meter at a residential home or commercial facility.	

'792 Claim 23 CC13	
23. The water use monitoring and leak detection apparatus of claim 2, further comprising said base station including an electronic water control valve wherein said base station is programmed to automatically turns off the main water supply when a leak is detected or alternately can send an alert signal when a leak is detected to ~~a~~ said cell phone, smart phone, mobile phone, or other mobile electronic communication device whereby a user is provided an election to send a command to the base station to control the electronic water control valve to turn off or leave on the main water supply.	
'792 Claim 28 CC13	
28. The water use monitoring apparatus of claim 1, further compromising one or more pressure sensors, said one or more pressure sensors in electrical connection with said first electrical circuity.	
'792 Claim 29 CC13	
29. The water use monitoring and leak detection apparatus of claim 1, further compromising one or more temperature sensors, said one or more temperature sensors in electrical connection with said first electrical circuity.	
'792 Claim 31 CC13	
31. The water use monitoring and leak detection apparatus of claim 2, further comprising one or more pressure sensors, said one or more pressure sensors in electrical connection with said first electrical circuity.	
'792 Claim 32 CC13	
32. The water use monitoring and leak detection apparatus of claim 2, further comprising one or more temperature sensors, said one or more temperature sensors in electrical connection with said first electrical circuity.	

<u>CC14</u>

US. Patent 9,749,792 Claim Chart - Lazar 7,626,511

'792 Claim 1 CC14	
A water use and monitoring and leak detection apparatus comprising:	Col. 1 lines 1-4 This invention relates to automatic meter reading (AMR) systems, and in particular to utility meters using a radio transmitter for transmitting metering data signals to a radio receiver in a network for collecting utility metering data.
a base station designed to be connected to a main water supply means;	
said base station includes a joint means for connecting to a cold/ambient water supply, or a joint means for connecting to a cold/ambient water supply and a joint means for connecting to a hot water supply, said base station have a joint means for connecting to outgoing water supply line(s) for a home residence, company or building structure;	
electrical circuitry including one or more microprocessors or microcontrollers with a power source contained with said base station apparatus;	Col 3 lines 37-42 Referring to FIG. 2, the transmitter assembly 10 also includes an electrical circuit typically formed on a circuit board and including a microelectronic CPU 30 operating according to a control program stored in a program memory 31, which in this case is an electrically erasable and programmable read only memory (EEPROM).
said power source is either AC powered, DC powered, or powered with one or more batteries, said power source is electrically connected to said electrical circuitry;	
one or more flow sensors in communication with a water supply, said one or more flow sensors in electrical communication with said electrical circuitry;	Col. 3 lines 2-6 The register 20 is preferably a unit that is commercially distributed by Badger Meter, Inc., the assignee of the present invention, under the trade designation "Recordall" Transmitter Register (RTR). Besides displaying units of consumption, this device 20 …
one or more wired or wireless electrical communication means, said or wired wireless electrical communication means having the capability to transfer water parameter, water energy and/or water quality information or data to one or more remote apparatuses, said wired or wireless electrical communication means utilizes protection technology to securely provide water use, water energy and/or water quality information and/or data in a confidential format;	Col. 3 lines 21-26 The transmitter assembly 10 communicates via low power RF signals with a receiver which can be a mobile receiver (not shown) in a vehicle 27. The pit transmitter assembly 10 transmits an electronic message that includes an identification code, meter reading data, and an error code for checking the data at the receiving end. **Does not disclose transferring water use data in a confidential format.**

said base station includes mesh-enabled circuitry that can communicate with other base stations for transferring water flow, water energy and/or water quality data;	
said base station(s) functioning as one or more access points that transfer said water flow, water energy and/or water quality data, using encryption and identification technology to an internet connection;	
said water flow, water energy and/or water quality data transferred over the internet connection to one or more remote computers or computer servers, and;	
said remote computers or servers allow registered owners and users to access their registered water flow, water energy and/or water quality data using a cell phone, smart phone, mobile phone, or a mobile electronic communication device.	
'792 Claim 2 CC14	
a base station in close proximity to a main water supply;	Col. 1 lines 1-4 This invention relates to automatic meter reading (AMR) systems, and in particular to utility meters using a radio transmitter for transmitting metering data signals to a radio receiver in a network for collecting utility metering data.
said base station includes a joint means for connecting to a cold/ambient water supply, or a joint means for connecting to a cold/ambient water supply and a joint means for connecting to a hot water supply, said base station have a joint means for connecting to outgoing water supply line(s) for a home residence, company or building structure;	
said base station further comprising a first power supply, said first power supply is either AC powered, DC powered, or powered with one or more batteries, said first power supply electrically connected to a first circuitry which has one or more microprocessors or microcontrollers;	Col 3 lines 37-42 Referring to FIG. 2, the transmitter assembly 10 also includes an electrical circuit typically formed on a circuit board and including a microelectronic CPU 30 operating according to a control program stored in a program memory 31, which in this case is an electrically erasable and programmable read only memory (EEPROM).
one or more water flow sensors in communication with a water supply, said one or more water flow sensors in electrical connection with a first electrical circuity;	Col. 3 lines 2-6 The register 20 is preferably a unit that is commercially distributed by Badger Meter, Inc., the assignee of the present invention, under the trade designation "Recordall" Transmitter Register (RTR). Besides displaying units of consumption, this device 20 …

said base station monitors and processes water parameter data including water flow, water energy, and/or water quality data;	
said base station includes software that controls and sequences the water parameter data and prepares said data for wired or wireless transfer;	
a receiving station, said receiving station having a second electrical circuitry including one or more second microprocessors, said receiving station remotely located from said base station;	
said receiving station having a second power supply, said second power supply is either AC power, DC power, or powered with one or more batteries, said second power supply electrically connected to a second circuitry;	
said first electrical circuitry of said base station is in wire or wireless communication with said second electrical circuity of said receiving station;	
said receiving station designed to establish Wi-Fi, Bluetooth or ZigBee electrical communication with a wireless router/server, and/or cellular communication with a cell tower technology, and any combinations thereof;	
said receiving station includes mesh-enabled circuitry that can communicate with other receiving stations for transferring water flow, water energy and/or water quality data to one or more access points;	
said receiving station or a custom transfer apparatus functioning as one or more access points for transferring said water flow, water energy and/or water quality data over an internet connection to one or more remote computers or computer servers; and	
said computer servers allow registered owners and users to access their registered water flow, water energy and/or water quality data using a cell phone, smart phone, mobile phone or a mobile electronic communication device.	

'792 Claim 5 CC14	
5. The water use monitoring and leak detection apparatus of claim 1, further comprising said base station including an electronic water control valve wherein said base station is programmed to automatically turns off the main water supply when a leak is detected or alternately can send an alert signal when a leak is detected to ~~a~~ said cell phone, smart phone, mobile phone, or other mobile electronic communication device wherein a user is provided an election to send a command to the base station to control the electronic water control valve to turn off or leave on the main water supply.	
'792 Claim 7 CC14	
7. The water use monitoring and leak detection apparatus of claim 1, further comprising a water use calibration mode for learning the patterns and signature of water use devices within a home, corporation, building or structure.	
'792 Claim 8 CC14	
8. The water use monitoring and leak detection apparatus of claim 1, further comprising automatic learning mode whereby learning software privately tracks an owner's water flow and volume use for a period, assigning water patterns and water signatures to each specific water use device.	
'792 Claim 9 CC14	
9. The water use monitoring and leak detection apparatus of claim 2, further comprising a water use calibration mode for learning the patterns and signature of water use devices within a home, corporation, building or structure.	
'792 Claim 10 CC14	
10. The water use monitoring and leak detection apparatus of claim 2, further comprising automatic learning mode whereby learning software privately tracks an owner's water flow and volume use for a period, assigning water patterns and water signatures to each specific water use device.	

'792 Claim 12 CC14	
12. The water use monitoring and leak detection apparatus of claim 1, further comprising a water control means or a variable water flow means, said water control means or variable water flow means ~~is~~ controlled by programming instructions from said microprocessor or microcontroller for turning on and off said water control means or setting a variable water flow means, said water control means or variable water flow means can be activated by an owner's or user's cell phone, smart phones, ~~or~~ mobile phone, or other mobile electronic communication device, or by a remote apparatus or computer or alternately activated by said one or more wireless or wired means controlled by a municipality or governmental agency.	
'792 Claim 14 CC14	
14. The water use monitoring and leak detection apparatus of claim 2, further comprising a water shut control means or a variable water flow means, said water control means or variable water flow means controlled by programming instructions from said microprocessor or microcontroller for turning on and off said water control means or setting a variable water flow means, said water control means or variable water flow means can be activated by an owner's or user's cell phone, smart phones, mobile phone, or other mobile electronic communication device, or by a remote apparatus or computer or alternately activated by said one or more wireless or wired means controlled by a municipality or governmental agency.	
'792 Claim 17 CC14	
17. The water use monitoring and leak detection apparatus of claim 1, wherein the base station can be incorporated into or serve as the pressure regulator or primary water meter at a residential home or commercial facility.	Abstract - Methods and systems are disclosed for monitoring water leaks within a home. A home network with various devices monitors these devices with a controller.
'792 Claim 19 CC14	
19. The water use monitoring and leak detection apparatus of claim 2, wherein the base station can be incorporated into or serve as the pressure regulator or primary water meter at a residential home or commercial facility.	

'792 Claim 23 CC14	
23. The water use monitoring and leak detection apparatus of claim 2, further comprising said base station including an electronic water control valve wherein said base station is programmed to automatically turns off the main water supply when a leak is detected or alternately can send an alert signal when a leak is detected to ~~a~~ said cell phone, smart phone, mobile phone, or other mobile electronic communication device whereby a user is provided an election to send a command to the base station to control the electronic water control valve to turn off or leave on the main water supply.	
'792 Claim 28 CC14	
28. The water use monitoring apparatus of claim 1, further compromising one or more pressure sensors, said one or more pressure sensors in electrical connection with said first electrical circuity.	
'792 Claim 29 CC14	
29. The water use monitoring and leak detection apparatus of claim 1, further compromising one or more temperature sensors, said one or more temperature sensors in electrical connection with said first electrical circuity.	
'792 Claim 31 CC14	
31. The water use monitoring and leak detection apparatus of claim 2, further comprising one or more pressure sensors, said one or more pressure sensors in electrical connection with said first electrical circuity.	
'792 Claim 32 CC14	
32. The water use monitoring and leak detection apparatus of claim 2, further comprising one or more temperature sensors, said one or more temperature sensors in electrical connection with said first electrical circuity.	

<u>CC15</u>

US. Patent 9,749,792 Claim Chart - Sanderford 9,253,754

'792 Claim 1 CC2	
A water use and monitoring and leak detection apparatus comprising:	Abstract - A communication system that relays data messages from or to a plurality of remote endpoints via RF gateways to a data accumulation site over one of a series of communication channels. The communication system monitors the signal-to-noise ratio of communication from each individual endpoint, which can be utility meters and related control or monitoring points, to a gateway Col. 5, lines 33-38 FIG. 1 illustrates a communication system **10** for communicating between a plurality of meters **12** and a back end data accumulation site or server **14**. In the embodiment shown in FIG. 1, the meters **12** can be any type of utility meter, such as an electricity meter, gas meter, or water meter.
a base station designed to be connected to a main water supply means;	
said base station includes a joint means for connecting to a cold/ambient water supply, or a joint means for connecting to a cold/ambient water supply and a joint means for connecting to a hot water supply, said base station have a joint means for connecting to outgoing water supply line(s) for a home residence, company or building structure;	
electrical circuitry including one or more microprocessors or microcontrollers with a power source contained with said base station apparatus;	
said power source is either AC powered, DC powered, or powered with one or more batteries, said power source is electrically connected to said electrical circuitry;	
one or more flow sensors in communication with a water supply, said one or more flow sensors in electrical communication with said electrical circuitry;	

one or more wired or wireless electrical communication means, said or wired wireless electrical communication means having the capability to transfer water parameter, water energy and/or water quality information or data to one or more remote apparatuses, said wired or wireless electrical communication means utilizes protection technology to securely provide water use, water energy and/or water quality information and/or data in a confidential format;	Col. 2, lines 13-19 The present disclosure relates to a system and method for controlling the communication of data between a multiplicity of endpoints (sometimes water gas or electricity meters, load controllers, PCT, utility displays, or the like) contained within a communication system and a single tier of intermediate gateway Col. 2, lines 26-33 During initial installation of meters in the communication system, each meter is initially assigned a default communication channel over which communications between the meter and the gateway will take place. The default communication channel is selected to have relatively long message duration since the signal-to-noise ratio between the meter and the gateway is initially unknown and the longer message duration improves link margin SNR. Col. 6, lines 39-45 In the embodiment shown, the communication bandwidth 38 is 150 kHz. As described previously, the communication bandwidth 38 is divided into individual channels A-E as well as the priority channel 36. Each of the channels 26-34 has a bandwidth of 25 kHz.
said base station includes mesh-enabled circuitry that can communicate with other base stations for transferring water flow, water energy and/or water quality data;	Col. 1, lines 55-60 Whereas mesh systems rely on multiple data hand offs between nodes, it is an object of this disclosure to minimize the number of handoffs thus improving latency. The minimal number of tiers is known to be one. Thus, an object of the disclosure is to provide reliable operation with a single communications tier. Col. 4, lines 37-43 Similar benefits accrue to low SNR endpoints such that a gateway may use a greater amount of outbound RF transmit power to communicate to a hard to reach meter, without having to use mesh-like intermediate tiers of communication.
said base station(s) functioning as one or more access points that transfer said water flow, water energy and/or water quality data, using encryption and identification technology to an internet connection;	Col. 10, lines 13-21 If a colliding message occurs before the initial message was complete and the colliding message had a signal level with sufficient C to I for demodulation, then the reserve \`aborts\` the first message and attempts to demodulate the second. In one embodiment, two DSP demodulators will attempt to simultaneously demodulate the first and the second colliding messages and utilize the message CRC or convolution encoding of encryption to validate which message was successful.

said water flow, water energy and/or water quality data transferred over the internet connection to one or more remote computers or computer servers, and;	Col. 5, lines 60-63 Each of the gateways 16 in turn is able to communicate over a public wide area network (WAN) 22. In the embodiment shown, the public WAN 22 is the internet. Thus, each of the gateways 16 is able to communicate with the one or more data accumulation sites 14 through the public WAN 22, as is known.
said remote computers or servers allow registered owners and users to access their registered water flow, water energy and/or water quality data using a cell phone, smart phone, mobile phone, or a mobile electronic communication device.	
'792 Claim 2 CC2	
a base station in close proximity to a main water supply;	Col. 5, lines 33-38 FIG. 1 illustrates a communication system **10** for communicating between a plurality of meters **12** and a back end data accumulation site or server **14**. In the embodiment shown in FIG. 1, the meters **12** can be any type of utility meter, such as an electricity meter, gas meter, or water meter.
said base station includes a joint means for connecting to a cold/ambient water supply, or a joint means for connecting to a cold/ambient water supply and a joint means for connecting to a hot water supply, said base station have a joint means for connecting to outgoing water supply line(s) for a home residence, company or building structure;	
said base station further comprising a first power supply, said first power supply is either AC powered, DC powered, or powered with one or more batteries, said first power supply electrically connected to a first circuitry which has one or more microprocessors or microcontrollers;	
one or more water flow sensors in communication with a water supply, said one or more water flow sensors in electrical connection with a first electrical circuity;	
said base station monitors and processes water parameter data including water flow, water energy, and/or water quality data;	
said base station includes software that controls and sequences the water parameter data and prepares said data for wired or wireless transfer;	Col. 1, lines 55-60 Whereas mesh systems rely on multiple data hand offs between nodes, it is an object of this disclosure to minimize the number of handoffs thus improving latency. The minimal number of tiers is known to be one. Thus, an object of the disclosure is to provide reliable operation with a single communications tier.

a receiving station, said receiving station having a second electrical circuitry including one or more second microprocessors, said receiving station remotely located from said base station;	
said receiving station having a second power supply, said second power supply is either AC power, DC power, or powered with one or more batteries, said second power supply electrically connected to a second circuitry;	
said first electrical circuitry of said base station is in wire or wireless communication with said second electrical circuity of said receiving station;	
said receiving station designed to establish Wi-Fi, Bluetooth or ZigBee electrical communication with a wireless router/server, and/or cellular communication with a cell tower technology, and any combinations thereof;	
said receiving station includes mesh-enabled circuitry that can communicate with other receiving stations for transferring water flow, water energy and/or water quality data to one or more access points;	Col. 1, lines 55-60 Whereas mesh systems rely on multiple data hand offs between nodes, it is an object of this disclosure to minimize the number of handoffs thus improving latency. The minimal number of tiers is known to be one. Thus, an object of the disclosure is to provide reliable operation with a single communications tier. Col. 4, lines 37-43 Similar benefits accrue to low SNR endpoints such that a gateway may use a greater amount of outbound RF transmit power to communicate to a hard to reach meter, without having to use mesh-like intermediate tiers of communication.
said receiving station or a custom transfer apparatus functioning as one or more access points for transferring said water flow, water energy and/or water quality data over an internet connection to one or more remote computers or computer servers; and	Col. 5, lines 60-63 Each of the gateways 16 in turn is able to communicate over a public wide area network (WAN) 22. In the embodiment shown, the public WAN 22 is the internet. Thus, each of the gateways 16 is able to communicate with the one or more data accumulation sites 14 through the public WAN 22, as is known.
said computer servers allow registered owners and users to access their registered water flow, water energy and/or water quality data using a cell phone, smart phone, mobile phone or a mobile electronic communication device.	

'792 Claim 5 CC2	
5. The water use monitoring and leak detection apparatus of claim 1, further comprising said base station including an electronic water control valve wherein said base station is programmed to automatically turns off the main water supply when a leak is detected or alternately can send an alert signal when a leak is detected to ~~a~~ said cell phone, smart phone, mobile phone, or other mobile electronic communication device wherein a user is provided an election to send a command to the base station to control the electronic water control valve to turn off or leave on the main water supply.	
'792 Claim 7 CC2	
7. The water use monitoring and leak detection apparatus of claim 1, further comprising a water use calibration mode for learning the patterns and signature of water use devices within a home, corporation, building or structure.	
'792 Claim 8 CC2	
8. The water use monitoring and leak detection apparatus of claim 1, further comprising automatic learning mode whereby learning software privately tracks an owner's water flow and volume use for a period, assigning water patterns and water signatures to each specific water use device.	
'792 Claim 9 CC2	
9. The water use monitoring and leak detection apparatus of claim 2, further comprising a water use calibration mode for learning the patterns and signature of water use devices within a home, corporation, building or structure.	
'792 Claim 10 CC2	
10. The water use monitoring and leak detection apparatus of claim 2, further comprising automatic learning mode whereby learning software privately tracks an owner's water flow and volume use for a period, assigning water patterns and water signatures to each specific water use device.	

'792 Claim 12 CC2	
12. The water use monitoring and leak detection apparatus of claim 1, further comprising a water control means or a variable water flow means, said water control means or variable water flow means ~~is~~ controlled by programming instructions from said microprocessor or microcontroller for turning on and off said water control means or setting a variable water flow means, said water control means or variable water flow means can be activated by an owner's or user's cell phone, smart phones, ~~or~~ mobile phone, or other mobile electronic communication device, or by a remote apparatus or computer or alternately activated by said one or more wireless or wired means controlled by a municipality or governmental agency.	
'792 Claim 14 CC2	
14. The water use monitoring and leak detection apparatus of claim 2, further comprising a water shut control means or a variable water flow means, said water control means or variable water flow means controlled by programming instructions from said microprocessor or microcontroller for turning on and off said water control means or setting a variable water flow means, said water control means or variable water flow means can be activated by an owner's or user's cell phone, smart phones, mobile phone, or other mobile electronic communication device, or by a remote apparatus or computer or alternately activated by said one or more wireless or wired means controlled by a municipality or governmental agency.	
'792 Claim 17 CC2	
17. The water use monitoring and leak detection apparatus of claim 1, wherein the base station can be incorporated into or serve as the pressure regulator or primary water meter at a residential home or commercial facility.	
'792 Claim 19 CC2	
19. The water use monitoring and leak detection apparatus of claim 2, wherein the base station can be incorporated into or serve as the pressure regulator or primary water meter at a residential home or commercial facility.	

'792 Claim 23 CC2	
23. The water use monitoring and leak detection apparatus of claim 2, further comprising said base station including an electronic water control valve wherein said base station is programmed to automatically turns off the main water supply when a leak is detected or alternately can send an alert signal when a leak is detected to ~~a~~ said cell phone, smart phone, mobile phone, or other mobile electronic communication device whereby a user is provided an election to send a command to the base station to control the electronic water control valve to turn off or leave on the main water supply.	
'792 Claim 28 CC2	
28. The water use monitoring apparatus of claim 1, further compromising one or more pressure sensors, said one or more pressure sensors in electrical connection with said first electrical circuity.	
'792 Claim 29 CC2	
29. The water use monitoring and leak detection apparatus of claim 1, further compromising one or more temperature sensors, said one or more temperature sensors in electrical connection with said first electrical circuity.	
'792 Claim 31 CC2	
31. The water use monitoring and leak detection apparatus of claim 2, further comprising one or more pressure sensors, said one or more pressure sensors in electrical connection with said first electrical circuity.	
'792 Claim 32 CC2	
32. The water use monitoring and leak detection apparatus of claim 2, further comprising one or more temperature sensors, said one or more temperature sensors in electrical connection with said first electrical circuity.	

<u>CC16</u>

US. Patent 9.749.792 Claim Chart - Olson 9.417.093

'792 Claim 1 CC16	
A water use and monitoring and leak detection apparatus comprising:	Abstract - The invention provides a method and several types of devices for converting meter reading signals into data messages including a first message (40) having meter data (44) representing consumption of a utility, and meter diagnostic status data (43), and a second message (60) having meter reverse flow data (63-65) and meter diagnostic data (66) particular to an electronic flow meter, and receiving said first message (40) and said second message (60) and converting first message and said second message to radio frequency signals (25) and transmitting said radio frequency signals (25) to a receiver (22, 24).
a base station designed to be connected to a main water supply means;	Fig. 2, 3, 4 and 5
said base station includes a joint means for connecting to a cold/ambient water supply, or a joint means for connecting to a cold/ambient water supply and a joint means for connecting to a hot water supply, said base station have a joint means for connecting to outgoing water supply line(s) for a home residence, company or building structure;	Fig. 2, 3, 4 and 5
electrical circuitry including one or more microprocessors or microcontrollers with a power source contained with said base station apparatus;	Fig. 7, Col. 4 lines 11-16 Referring to FIG. 7, the housing 20' in FIGS. 3 and 5, encloses an electrical signal processing section 50 typically formed on a circuit board 26 and including a microelectronic CPU 51 operating according to a control program of program instructions stored in a program memory 52, which may be internal to the CPU 51.
said power source is either AC powered, DC powered, or powered with one or more batteries, said power source is electrically connected to said electrical circuitry;	Fig. 7, Col. 4 lines 11-16 Referring to FIG. 7, the housing 20' in FIGS. 3 and 5, encloses an electrical signal processing section 50 typically formed on a circuit board 26 and including a microelectronic CPU 51 operating according to a control program of program instructions stored in a program memory 52, which may be internal to the CPU 51.

one or more flow sensors in communication with a water supply, said one or more flow sensors in electrical communication with said electrical circuitry;	Col. 6, lines 65-76 and Col. 7, line 1 It should now be apparent how the first message and second message contribute to increasing the diagnostic data available in the two messages due to the capabilities of an ultrasonic flow meter.
one or more wired or wireless electrical communication means, said or wired wireless electrical communication means having the capability to transfer water parameter, water energy and/or water quality information or data to one or more remote apparatuses, said wired or wireless electrical communication means utilizes protection technology to securely provide water use, water energy and/or water quality information and/or data in a confidential format;	Col. 3, lines 22-25 …In a fully "integrated version" of the invention seen in FIG. 3, a housing 20' encloses both meter register and transmitter formed on a circuit board 26 with an antenna 29 for transmitting signals directly through the pit lid 15 to a radio signal receiver 24. **Does not disclose transferring water use data in a confidential format.**
said base station includes mesh-enabled circuitry that can communicate with other base stations for transferring water flow, water energy and/or water quality data;	
said base station(s) functioning as one or more access points that transfer said water flow, water energy and/or water quality data, using encryption and identification technology to an internet connection;	
said water flow, water energy and/or water quality data transferred over the internet connection to one or more remote computers or computer servers, and;	Col. 3, lines 44-47 In the present invention, the transmitter assemblies 10, 10", 26 also communicate, via RF signals with a fixed receiver 22 installed on a utility pole 23 seen in FIG. 1, within a range of up to one thousand feet of the transmitter unit 10. Col. 5, lines 5-16 FIGS. 8-11 show the data in the two messages referred to more generally above. The messages contain data for implementing various alarm conditions, including a reverse flow alarm, a potential leak alarm, a stuck meter condition, (no usage for 30 days), a tamper alarm, an empty pipe alarm, a low temperature alarm and an end-of-life notification. The reverse flow alarm, the empty pipe condition and the end-of-life notification are conditions which are particularly related to electronic flow meters. The low temperature condition is a feature of the ultrasonic flow meter that is available, and is sensed with the addition of a temperature sensor 39 to the meter housing assembly 16, 20 as seen in FIG. 4.

said remote computers or servers allow registered owners and users to access their registered water flow, water energy and/or water quality data using a cell phone, smart phone, mobile phone, or a mobile electronic communication device.	
'792 Claim 2 CC16	
a base station in close proximity to a main water supply;	Abstract - The invention provides a method and several types of devices for converting meter reading signals into data messages including a first message (40) having meter data (44) representing consumption of a utility, and meter diagnostic status data (43), and a second message (60) having meter reverse flow data (63-65) and meter diagnostic data (66) particular to an electronic flow meter, and receiving said first message (40) and said second message (60) and converting first message and said second message to radio frequency signals (25) and transmitting said radio frequency signals (25) to a receiver (22, 24).
said base station includes a joint means for connecting to a cold/ambient water supply, or a joint means for connecting to a cold/ambient water supply and a joint means for connecting to a hot water supply, said base station have a joint means for connecting to outgoing water supply line(s) for a home residence, company or building structure;	Fig. 2, 3, 4 and 5
said base station further comprising a first power supply, said first power supply is either AC powered, DC powered, or powered with one or more batteries, said first power supply electrically connected to a first circuitry which has one or more microprocessors or microcontrollers;	Fig. 7, Col. 4 lines 11-16 Referring to FIG. 7, the housing 20' in FIGS. 3 and 5, encloses an electrical signal processing section 50 typically formed on a circuit board 26 and including a microelectronic CPU 51 operating according to a control program of program instructions stored in a program memory 52, which may be internal to the CPU 51.
one or more water flow sensors in communication with a water supply, said one or more water flow sensors in electrical connection with a first electrical circuity;	Col. 6, lines 65-76 and Col. 7, line 1 It should now be apparent how the first message and second message contribute to increasing the diagnostic data available in the two messages due to the capabilities of an ultrasonic flow meter.
said base station monitors and processes water parameter data including water flow, water energy, and/or water quality data;	

said base station includes software that controls and sequences the water parameter data and prepares said data for wired or wireless transfer;	
a receiving station, said receiving station having a second electrical circuitry including one or more second microprocessors, said receiving station remotely located from said base station;	
said receiving station having a second power supply, said second power supply is either AC power, DC power, or powered with one or more batteries, said second power supply electrically connected to a second circuitry;	
said first electrical circuitry of said base station is in wire or wireless communication with said second electrical circuity of said receiving station;	
said receiving station designed to establish Wi-Fi, Bluetooth or ZigBee electrical communication with a wireless router/server, and/or cellular communication with a cell tower technology, and any combinations thereof;	
said receiving station includes mesh-enabled circuitry that can communicate with other receiving stations for transferring water flow, water energy and/or water quality data to one or more access points;	
said receiving station or a custom transfer apparatus functioning as one or more access points for transferring said water flow, water energy and/or water quality data over an internet connection to one or more remote computers or computer servers; and	
said computer servers allow registered owners and users to access their registered water flow, water energy and/or water quality data using a cell phone, smart phone, mobile phone or a mobile electronic communication device.	

'792 Claim 5 CC16	
5. The water use monitoring and leak detection apparatus of claim 1, further comprising said base station including an electronic water control valve wherein said base station is programmed to automatically turns off the main water supply when a leak is detected or alternately can send an alert signal when a leak is detected to ~~a~~ said cell phone, smart phone, mobile phone, or other mobile electronic communication device wherein a user is provided an election to send a command to the base station to control the electronic water control valve to turn off or leave on the main water supply.	
'792 Claim 7 CC16	
7. The water use monitoring and leak detection apparatus of claim 1, further comprising a water use calibration mode for learning the patterns and signature of water use devices within a home, corporation, building or structure.	
'792 Claim 8 CC16	
8. The water use monitoring and leak detection apparatus of claim 1, further comprising automatic learning mode whereby learning software privately tracks an owner's water flow and volume use for a period, assigning water patterns and water signatures to each specific water use device.	
'792 Claim 9 CC16	
9. The water use monitoring and leak detection apparatus of claim 2, further comprising a water use calibration mode for learning the patterns and signature of water use devices within a home, corporation, building or structure.	
'792 Claim 10 CC16	
10. The water use monitoring and leak detection apparatus of claim 2, further comprising automatic learning mode whereby learning software privately tracks an owner's water flow and volume use for a period, assigning water patterns and water signatures to each specific water use device.	

'792 Claim 12 CC16	
12. The water use monitoring and leak detection apparatus of claim 1, further comprising a water control means or a variable water flow means, said water control means or variable water flow means ~~is~~ controlled by programming instructions from said microprocessor or microcontroller for turning on and off said water control means or setting a variable water flow means, said water control means or variable water flow means can be activated by an owner's or user's cell phone, smart phones, ~~or~~ mobile phone, or other mobile electronic communication device, or by a remote apparatus or computer or alternately activated by said one or more wireless or wired means controlled by a municipality or governmental agency.	
'792 Claim 14 CC16	
14. The water use monitoring and leak detection apparatus of claim 2, further comprising a water shut control means or a variable water flow means, said water control means or variable water flow means controlled by programming instructions from said microprocessor or microcontroller for turning on and off said water control means or setting a variable water flow means, said water control means or variable water flow means can be activated by an owner's or user's cell phone, smart phones, mobile phone, or other mobile electronic communication device, or by a remote apparatus or computer or alternately activated by said one or more wireless or wired means controlled by a municipality or governmental agency.	
'792 Claim 17 CC16	
17. The water use monitoring and leak detection apparatus of claim 1, wherein the base station can be incorporated into or serve as the pressure regulator or primary water meter at a residential home or commercial facility.	
'792 Claim 19 CC16	
19. The water use monitoring and leak detection apparatus of claim 2, wherein the base station can be incorporated into or serve as the pressure regulator or primary water meter at a residential home or commercial facility.	

'792 Claim 23 CC16	
23. The water use monitoring and leak detection apparatus of claim 2, further comprising said base station including an electronic water control valve wherein said base station is programmed to automatically turns off the main water supply when a leak is detected or alternately can send an alert signal when a leak is detected to ~~a~~ said cell phone, smart phone, mobile phone, or other mobile electronic communication device whereby a user is provided an election to send a command to the base station to control the electronic water control valve to turn off or leave on the main water supply.	
'792 Claim 28 CC16	
28. The water use monitoring apparatus of claim 1, further compromising one or more pressure sensors, said one or more pressure sensors in electrical connection with said first electrical circuity.	
'792 Claim 29 CC16	
29. The water use monitoring and leak detection apparatus of claim 1, further compromising one or more temperature sensors, said one or more temperature sensors in electrical connection with said first electrical circuity.	Col. 3, line 57-60 The assembly also includes two ultrasonic transducers 30, 31, a temperature sensor 39, a signal processing section, 50, and one or more batteries 37. Col. 4, lines 9-10 A temperature sensor 39 is also positioned with one end projecting into the flow stream 35.
'792 Claim 31 CC16	
31. The water use monitoring and leak detection apparatus of claim 2, further comprising one or more pressure sensors, said one or more pressure sensors in electrical connection with said first electrical circuity.	
'792 Claim 32 CC16	
32. The water use monitoring and leak detection apparatus of claim 2, further comprising one or more temperature sensors, said one or more temperature sensors in electrical connection with said first electrical circuity.	Col. 3, line 57-60 The assembly also includes two ultrasonic transducers 30, 31, a temperature sensor 39, a signal processing section, 50, and one or more batteries 37. Col. 4, lines 9-10 A temperature sensor 39 is also positioned with one end projecting into the flow stream 35.

CC17

US. Patent 9,749,792 Claim Chart - Blackwell 9,709,421

'792 Claim 1 CC10	
A water use and monitoring and leak detection apparatus comprising:	Abstract - A method and a system for collection of meter readings from meter reading and transmitting devices (12, 14) and for viewing on a web-enabled wireless communication device (28) comprises addressing at least one receiver (15) through the Internet (21) and obtaining a data file of meter data for a plurality of meter reading devices (12, 14) that have previously communicated with the receiver (15)…
a base station designed to be connected to a main water supply means;	
said base station includes a joint means for connecting to a cold/ambient water supply, or a joint means for connecting to a cold/ambient water supply and a joint means for connecting to a hot water supply, said base station have a joint means for connecting to outgoing water supply line(s) for a home residence, company or building structure;	
electrical circuitry including one or more microprocessors or microcontrollers with a power source contained with said base station apparatus;	Col. 2 lines 34-37 A plurality of meter reading devices 12 each include a utility meter, a transducer and an RF (radio frequency) transmitter.
said power source is either AC powered, DC powered, or powered with one or more batteries, said power source is electrically connected to said electrical circuitry;	Col. 2 lines 34-37 A plurality of meter reading devices 12 each include a utility meter, a transducer and an RF (radio frequency) transmitter.
one or more flow sensors in communication with a water supply, said one or more flow sensors in electrical communication with said electrical circuitry;	Col. 2 lines 34-37 A plurality of meter reading devices 12 each include a utility meter, a transducer and an RF (radio frequency) transmitter.

one or more wired or wireless electrical communication means, said or wired wireless electrical communication means having the capability to transfer water parameter, water energy and/or water quality information or data to one or more remote apparatuses, said wired or wireless electrical communication means utilizes protection technology to securely provide water use, water energy and/or water quality information and/or data in a confidential format;	Col. 2 lines 59-63 The devices 12, 14 transmit data-encoded RF signals over low power RF frequencies either in the non FCC-licensed ISM (Industrial-Scientific-Medical) band from 902 MHz to 928 MHz or in the FCC-licensed frequencies such as 150-200 Mhz, 325 MHz, 433.92 MHz or from 450 to 470 MHz. **Does not disclose transferring water use data in a confidential format.**
said base station includes mesh-enabled circuitry that can communicate with other base stations for transferring water flow, water energy and/or water quality data;	
said base station(s) functioning as one or more access points that transfer said water flow, water energy and/or water quality data, using encryption and identification technology to an internet connection;	
said water flow, water energy and/or water quality data transferred over the internet connection to one or more remote computers or computer servers, and;	Abstract - A method and a system for collection of meter readings from meter reading and transmitting devices (12, 14) and for viewing on a web-enabled wireless communication device (28) comprises addressing at least one receiver (15) through the Internet (21) and obtaining a data file of meter data for a plurality of meter reading devices (12, 14) that have previously communicated with the receiver (15).
said remote computers or servers allow registered owners and users to access their registered water flow, water energy and/or water quality data using a cell phone, smart phone, ~~or~~ mobile phone, or a mobile electronic communication device.	Abstract - The meter data is then accessed and displayed at a customer demonstration site using a handheld wireless smart phone (28) which receives a web page (22) that is reduced in size for transmission through the cellular network to the smart phone (28). Col. 3, lines 22-28 These web pages can be accessed through a GSM relay network and servers 20 that can convert HTML pages to web pages of a type that can be displayed on the visual display portion of a wireless handheld device, such as a BlackBerry.TM. smart phone, as disclosed in U.S. Pat. No. 7,302,637, issued Nov. 27, 2007, the disclosure of which is incorporated here by reference.

'792 Claim 2 CC10	
a base station in close proximity to a main water supply;	Abstract - A method and a system for collection of meter readings from meter reading and transmitting devices (12, 14) and for viewing on a web-enabled wireless communication device (28) comprises addressing at least one receiver (15) through the Internet (21) and obtaining a data file of meter data for a plurality of meter reading devices (12, 14) that have previously communicated with the receiver (15)…
said base station includes a joint means for connecting to a cold/ambient water supply, or a joint means for connecting to a cold/ambient water supply and a joint means for connecting to a hot water supply, said base station have a joint means for connecting to outgoing water supply line(s) for a home residence, company or building structure;	
said base station further comprising a first power supply, said first power supply is either AC powered, DC powered, or powered with one or more batteries, said first power supply electrically connected to a first circuitry which has one or more microprocessors or microcontrollers;	Col. 2 lines 34-37 A plurality of meter reading devices 12 each include a utility meter, a transducer and an RF (radio frequency) transmitter.
one or more water flow sensors in communication with a water supply, said one or more water flow sensors in electrical connection with a first electrical circuity;	Col. 2 lines 34-38 A plurality of meter reading devices 12 each include a utility meter, a transducer and an RF (radio frequency) transmitter.
said base station monitors and processes water parameter data including water flow, water energy, and/or water quality data;	
said base station includes software that controls and sequences the water parameter data and prepares said data for wired or wireless transfer;	

a receiving station, said receiving station having a second electrical circuitry including one or more second microprocessors, said receiving station remotely located from said base station;	
said receiving station having a second power supply, said second power supply is either AC power, DC power, or powered with one or more batteries, said second power supply electrically connected to a second circuitry;	
said first electrical circuitry of said base station is in wire or wireless communication with said second electrical circuity of said receiving station;	
said receiving station designed to establish Wi-Fi, Bluetooth or ZigBee electrical communication with a wireless router/server, and/or cellular communication with a cell tower technology, and any combinations thereof;	
said receiving station includes mesh-enabled circuitry that can communicate with other receiving stations for transferring water flow, water energy and/or water quality data to one or more access points;	
said receiving station or a custom transfer apparatus functioning as one or more access points for transferring said water flow, water energy and/or water quality data over an internet connection to one or more remote computers or computer servers; and	

said computer servers allow registered owners and users to access their registered water flow, water energy and/or water quality data using a cell phone, smart phone, mobile phone or a mobile electronic communication device.	Abstract - The meter data is then accessed and displayed at a customer demonstration site using a handheld wireless smart phone (28) which receives a web page (22) that is reduced in size for transmission through the cellular network to the smart phone (28). Col. 3, lines 22-28 These web pages can be accessed through a GSM relay network and servers 20 that can convert HTML pages to web pages of a type that can be displayed on the visual display portion of a wireless handheld device, such as a BlackBerry.TM. smart phone, as disclosed in U.S. Pat. No. 7,302,637, issued Nov. 27, 2007, the disclosure of which is incorporated here by reference.
'792 Claim 5 CC10	
5. The water use monitoring and leak detection apparatus of claim 1, further comprising said base station including an electronic water control valve wherein said base station is programmed to automatically turns off the main water supply when a leak is detected or alternately can send an alert signal when a leak is detected to ~~a~~ said cell phone, smart phone, mobile phone, or other mobile electronic communication device wherein a user is provided an election to send a command to the base station to control the electronic water control valve to turn off or leave on the main water supply.	
'792 Claim 7 CC10	
7. The water use monitoring and leak detection apparatus of claim 1, further comprising a water use calibration mode for learning the patterns and signature of water use devices within a home, corporation, building or structure.	
'792 Claim 8 CC10	
8. The water use monitoring and leak detection apparatus of claim 1, further comprising automatic learning mode whereby learning software privately tracks an owner's water flow and volume use for a period, assigning water patterns and water signatures to each specific water use device.	

'792 Claim 9 CC10	
9. The water use monitoring and leak detection apparatus of claim 2, further comprising a water use calibration mode for learning the patterns and signature of water use devices within a home, corporation, building or structure.	
'792 Claim 10 CC10	
10. The water use monitoring and leak detection apparatus of claim 2, further comprising automatic learning mode whereby learning software privately tracks an owner's water flow and volume use for a period, assigning water patterns and water signatures to each specific water use device.	
'792 Claim 12 CC10	
12. The water use monitoring and leak detection apparatus of claim 1, further comprising a water control means or a variable water flow means, said water control means or variable water flow means ~~is~~ controlled by programming instructions from said microprocessor or microcontroller for turning on and off said water control means or setting a variable water flow means, said water control means or variable water flow means can be activated by an owner's or user's cell phone, smart phones, ~~or~~ mobile phone, or other mobile electronic communication device, or by a remote apparatus or computer or alternately activated by said one or more wireless or wired means controlled by a municipality or governmental agency.	
'792 Claim 14 CC10	
14. The water use monitoring and leak detection apparatus of claim 2, further comprising a water shut control means or a variable water flow means, said water control means or variable water flow means controlled by programming instructions from said microprocessor or microcontroller for turning on and off said water control means or setting a variable water flow means, said water control means or variable water flow means can be activated by an owner's or user's cell phone, smart phones, mobile phone, or other mobile electronic communication device, or by a remote apparatus or computer or alternately activated by said one or more wireless or wired means controlled by a municipality or governmental agency.	

'792 Claim 17 CC10	
17. The water use monitoring and leak detection apparatus of claim 1, wherein the base station can be incorporated into or serve as the pressure regulator or primary water meter at a residential home or commercial facility.	
'792 Claim 19 CC10	
19. The water use monitoring and leak detection apparatus of claim 2, wherein the base station can be incorporated into or serve as the pressure regulator or primary water meter at a residential home or commercial facility.	
'792 Claim 23 CC10	
23. The water use monitoring and leak detection apparatus of claim 2, further comprising said base station including an electronic water control valve wherein said base station is programmed to automatically turns off the main water supply when a leak is detected or alternately can send an alert signal when a leak is detected to ~~a~~ said cell phone, smart phone, mobile phone, or other mobile electronic communication device whereby a user is provided an election to send a command to the base station to control the electronic water control valve to turn off or leave on the main water supply.	
'792 Claim 28 CC10	
28. The water use monitoring apparatus of claim 1, further compromising one or more pressure sensors, said one or more pressure sensors in electrical connection with said first electrical circuity.	
'792 Claim 29 CC10	
29. The water use monitoring and leak detection apparatus of claim 1, further compromising one or more temperature sensors, said one or more temperature sensors in electrical connection with said first electrical circuity.	
'792 Claim 31 CC10	
31. The water use monitoring and leak detection apparatus of claim 2, further comprising one or more pressure sensors, said one or more pressure sensors in electrical connection with said first electrical circuity.	
'792 Claim 32 CC10	
32. The water use monitoring and leak detection apparatus of claim 2, further comprising one or more temperature sensors, said one or more temperature sensors in electrical connection with said first electrical circuity.	